MANUFACTURES

The Third Book of

The Great American Industries Series

by

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PREFACE

The World War taught us the value of our great industries and their interdependence. From the earth we obtain food, through which life is sustained, minerals that supply us with heat and power, and raw material for our manufactures. But without transportation these necessities could not be distributed where they are needed, and we should have no commerce.

The boys and girls of today are the industrial workers of the future, and industrial subjects should receive due attention in their education. It is most essential that all Americans have a proper knowledge of their country's resources. The books of the Great American Industries Series — "Minerals," "Products of the Soil," "Manufactures," "Transportation" and "Farm Animals and Farm Crops" — supply this necessary information in a non-technical but instructive manner.

Great
American Industries

Minerals
Products of the Soil
Manufactures
Transportation
Farm Animals *and*
Farm Crops

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the materials and forces around him to enable him to add to his comfort and happiness.

Sticks and stones were probably the first tools used. Man discovered in the course of time that he could so wield these as to increase his power in overcoming obstacles. The stick served as a lever, and the stone as a weight. After a while he fastened these together and had a hammer with the stone for the head and the stick for the handle. Many stones shaped for such hammers have been found in caves and other places where men lived before the days of civilization. Our first parents also learned that it was easier to walk up a gentle slope than to lift themselves over a precipice, or climb a tree. They made use of this knowledge in raising great weights, and we have the inclined plane as the next mechanical device found useful. Further study led to the discovery, that, if a lever be arranged so as to move around a fixed point of support, its action becomes continuous. This crude arrangement grew into the wheel attached to an axle, and was the forerunner of the modern machine known as the wheel and axle. The pulley, the wedge, and the screw were each likewise developed from man's necessity. Each was discovered in the attempt of the race to master difficulties, and make a more extensive use of the forces and objects with which they were surrounded.

These few simple contrivances are known as the mechanical powers, or elements of machines, because one or more of them is found in every tool and machine that has ever been constructed. However complicated a machine may be, and however wonderful and delicate its work may appear, we must always remember that it is an ingenious combination of the elements of machinery, so modified and adjusted as to fit them for doing the particular work for which that machine was intended.

Domestic animals were probably used before simple tools were combined into machines. We read, in the Old Testament and other books that tell us about the customs of ancient people, that they used animals for treading out the grain on the threshing-floor, and in tilling the soil. The ass and the camel are mentioned as beasts of burden by these early writers.

The invention of the wheel is older than history. We can not trace civilization back far enough to discover its origin. The earliest accounts of the Egyptians speak of their war chariots, and the ancient Greeks were acquainted with the elements of machines long before the building of the Parthenon, which was nearly 500 B. C. The first use of the wheel was undoubtedly for raising water, the power being supplied by men treading on the circumference.

At a very early date water wheels were used

for grinding corn, and both wind and water were probably used to turn machinery before domestic animals were employed for the same purpose. At the present time it would seem that we had discovered every available force which nature has given us for operating machinery. For convenience we will study this subject under the following heads: The Power of Domestic Animals, The Power of Water, The Power of the Atmosphere, The Power of Steam, The Power of Electricity.

DOMESTIC ANIMALS

As already stated, the first use of domestic animals was probably in treading out grain on the threshing-floor, and carrying burdens. From this beginning it was quite easy to invent the yoke and train the animal to haul the load instead of carrying it. If the ox could haul a cart, why not a plow or a drag? Guided by such reasoning the agriculturist soon made the ox and the ass his chief means of support. It seems that the horse was for centuries regarded as an aristocrat. He carried his master on all occasions of public ceremony, bore him in battle, or, hitched to the war chariot, dashed at the enemy in the deadly charge, but he stands aloof from domestic service.

The transition from a straight to a circular path for the yoked animal was very natural, and

we find the ox turning the wheel as well as hauling the cart. Such a device is called a sweep, and only a few years ago it was in quite common use, but now is nearly entirely supplanted by the engine. Sweeps were most frequently seen in small brickyards, where a horse furnished the power for grinding the clay; at small shafts where they were used for raising coal, and in the grainfields where they were so arranged that horse power was used for running large threshers. They were also frequently used for operating small elevators. In all these arrangements a system of gearing, or bolts and pulleys, changes the slow motion of the animal to the speed required for the work of the machine. In case of the threshing machine the power was so arranged as to employ six or more horses at a time. But the horse power threshing machine is now entirely supplanted by the engine driven machine.

The treadmill is a later device for using animal power in operating machinery, and these machines were formerly much in use in localities having small farms. The most common form of the treadmill, known as the horse power, consists of a series of narrow planks, called lags, fastened at each end of a chain belt which passes over pulleys at the ends of the machine. The forward pulley is considerably the larger, so that the lags form an inclined plane. The whole arrange-

ment moves on rollers so adjusted as to have as little friction as possible. When in use the forward end of the power is elevated from twelve to eighteen inches, as this increases the effective working. A frame from three and a half to four feet high incloses the sides and forward end so as to keep the animal, usually a horse, from stepping off. The motive power of the treadmill here described is caused by the weight of the animal, and is equal to the force required to haul him up the incline formed by the lags. As the platform upon which he stands begins to move backward, the horse steps forward. One step leads to another, and the horse is soon walking up this moving plane at his usual gait. The speed is regulated by the work done, or by a brake upon the fly wheel connected with the power.

These machines are made for one and two horses, and are very convenient and efficient. They are easily moved, occupy but small space, and utilize nearly all the power developed. They are used for threshing grain on small farms, sawing wood, and cutting ensilage. Smaller patterns are sometimes made for light work, such as churning, running cream separators, and turning grindstones. The power in these is usually furnished by a sheep or a large dog.

Another sort of treadmill consists of a large

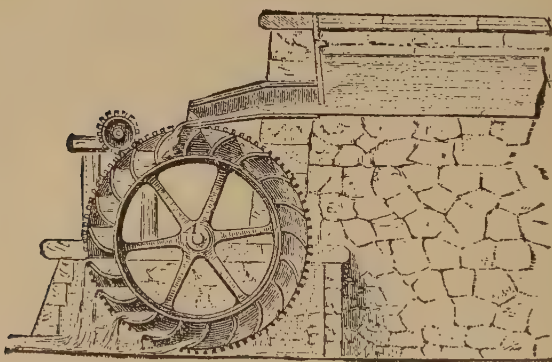
circular platform fastened to a vertical shaft passing through its center. The platform is inclined, and the horse is so tethered that he walks up the incline. This device was used formerly to some extent in grain elevators, but was not very satisfactory.

WATER WHEELS

Water wheels are structures for using the weight and pressure of water in running machinery. They were probably man's first successful attempt to use the forces of nature for this purpose. For ages they were huge and crude affairs, yet they were a great advance over anything that had preceded them; they have served their purpose well, and occupy an important place in the industrial history of the world. The first device for making use of the power of water to produce rotary motion was a very simple one, but it involved the principle employed in nearly all the motors that followed. The modern rotary lawn sprinkler is its best representative. Water was let into a long, vertical tube mounted on a central axis. Two or more arms extended from the bottom of this tube in a horizontal direction. There was a small hole at the outer end of each arm, and these holes were so made that the water flowed from all in the same direction. Water was poured into the large tube, and the reaction of the air upon the streams flowing

from the arms caused the machine to revolve quite rapidly. This device, however, could not utilize enough power to make it practical, hence it was scarcely more than a scientific toy.

The water wheels in practical use are known as the overshot, undershot, breast and turbine wheels. The overshot wheel furnished the power for nearly all the saw and grist mills, machine shops and factories in the country for a



OVERSHOT WHEEL

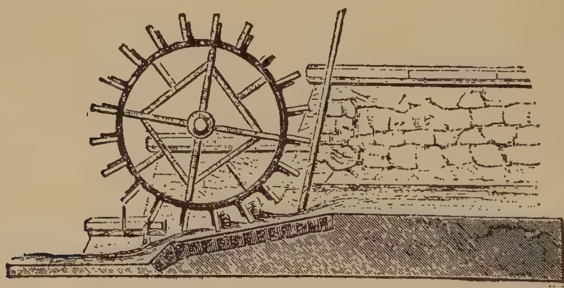
long time after it was settled. Without it our forefathers would have suffered even greater hardships than fell to their lot, for it made possible the operation of a mill wherever a small stream could be dammed. The settlers harnessed the numerous mountain streams, and made them perform their hardest tasks, and at

the present time these wheels may be seen occasionally in the hilly country of the eastern States. This style of water wheel was always the largest wheel in the mill, and its size depended upon the volume of water which could be obtained and the power required. In the ordinary country mill or shop, the wheel would be from sixteen to twenty feet in diameter; but in large factories they have been constructed with a diameter of seventy-five and even ninety feet. One of these old wheels may have suggested the famous Ferris Wheel to its inventor; who knows?

The width of the rim varied with the diameter. A twenty-foot wheel would usually be from six to eight feet wide. The rim is made into a series of buckets or, more correctly speaking, troughs which extend across its entire width. These buckets are so arranged that the water which strikes the wheel at the top fills them at the same time that the current pushes against the side of the one it strikes, and tends to push it along and so turn the wheel. The full buckets are on the falling side of the wheel, and empty themselves when they have reached the lowest point in the circumference. The motive power is in the weight of water in the buckets, and the current adds a little to the effective force. This wheel can be used where there is a good fall of water, and often does excellent work with only

a small stream. Its motion is steady and uniform, and it was the standard motor until the steam engine and the turbine replaced it.

The undershot wheel has floats in the place of buckets. It is so arranged that the water strikes it at the bottom, and the power is derived from the force of the current against the floats. It is designed for streams having a large volume of water and slight fall. Its successful operation



UNDERSHOT WHEEL

requires a very strong current, as it utilizes only a small portion of the power.

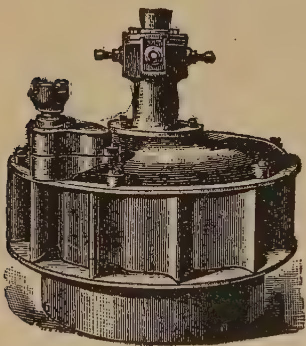
The breast wheel is the result of an attempt to improve the undershot, with which it is identical in construction; the difference lies in the method of applying the power. In the breast wheel the water is let on just below the axis and the floats move from this point to the lowest point in their rotation in a water-tight box, so that the weight

of the water is added to the force of the current. This increases the power over that of the undershot wheel, but does not make it equal to that of the overshot.

The turbine wheel is a return to first principles on an improved plan. It utilizes the reaction of the current as the first described device did. The difference is that the modern wheel is inclosed in a tight box so that the entire force of the water is used. Turbines revolve upon a vertical axis, and are known as horizontal wheels. The wheel is usually set at the lowest possible level so as to give it the greatest fall of water. The water is carried through a vertical tube called the "penstock." Just before it passes out to the wheel it is forced between spiral partitions which give it a rotary motion. As it leaves the "penstock" it comes in contact with the floats on the wheel which are so arranged as to turn the current in the opposite direction from what it is flowing. The reaction of the current together with the weight of the water in the "penstock" furnishes the motive power.


PLAN OF THE TURBINE WHEEL

Turbines differ from other wheels in having the water strike all the floats continually when they are in motion. The wheels are small, usually being only a few feet in diameter, but their construction is so perfect that they utilize nearly all the power which the water supplies. They are very efficient, and are found in all shops and factories where water power can be used. There are several different patterns of turbine, but all work on the same principle. The water supply is regulated by a gate, and, as this varies with the speed, most wheels in large factories have the gate connected with a machine called the governor, which so regulates the supply of power as to keep the motion steady and the speed uniform.



A TURBINE WHEEL

The largest turbines in the world are at Niagara, where a portion of the great cataract has been turned to the operation of machinery. A brief description will give some idea of what has been attempted and accomplished in the construction of this plant. A canal draws the water from the river about a mile above the falls on the American side. The wheels are set at the

bottom of a pit 178 feet deep, and 140 long, and 18 wide. From the lower end of this pit, a tunnel was constructed connecting with the river below the falls. The tunnel is about a mile and a quarter in length. There is room in the pit for ten turbines. Each wheel is double, that is, there are two wheels, one above the other on the same axis; each is rated at 5,000 horse power. They are employed in generating electricity for use in cities situated a long distance from the falls. Dynamos are attached to the vertical shaft of the wheel so as to form a cap over the pit. The current operates machinery and street cars in Buffalo and has been carried as far as New York City and been successfully used for operating light machines.

Another pattern of water wheel which is very effective where a small stream with high pressure can be obtained, is a small iron wheel with cup-shaped buckets on its circumference. The water issues from a nozzle so placed that the stream strikes the lowest bucket horizontally. These wheels are usually known as water motors. Under high pressure 100 horse power has been attained with a stream an inch in diameter.

The invention of these various patterns of water wheels shows that wheels have been devised to enable us to use the power of water for operating machinery under almost every condition in which it may be found.

WINDMILLS

Windmills are undoubtedly of much later origin than water wheels. In the early part of this century a German professor made a thorough study of the history of this invention. The earliest date having reference to the use of the windmill was 818 A.D. The record shows that these mills were used in Bohemia at this time. The mill is again mentioned in writings of 1105 and 1143 A.D., but no authentic information about their construction is found until a much later date. It seems to have been much more difficult for men to utilize the power of the air with its ever-shifting currents than it was to harness the stream confined within its own banks. Be this as it may, windmills have been in use for a number of centuries, and are more generally employed now than ever before.

A windmill has four essential parts: the wind wheel, the axis which communicates the power, the necessary wheels and pulleys for transmitting the power to the machinery, and the frame work which supports the structure. Nearly all patterns of windmills have a vertical wind wheel mounted on a horizontal axis, as this arrangement gives by far the best results. In the old-style mill with a large wheel used for grinding grain, the wheel is inclined so that the surface which the wind strikes has a slightly upward

slant. This arrangement has some advantage over that of the strictly vertical wheel.

The wind wheels have four arms arranged at right angles to each other, and have a length of

OLD-FASHIONED WINDMILL

thirty or forty feet. These arms are called "whips," and are either a single shaft containing pins on which canvas can be fastened, or strong frames with slats that serve for floats against

which the wind strikes. In either case the width of the whip increases from the center toward the circumference of the wheel. If canvas forms the resisting surface, it is fastened to the arm in the form of a spiral. If slats are used, they are so arranged as to form an angle of about 60 degrees with the wind, and are placed far enough apart to allow the current of air to readily pass between them.

The reaction of the wind against the whips turns the wheel, and this sets the machinery in motion. You see that the principle is just the same as that used with the water wheel, and the difference in the two machines is simply in their construction. Each wheel is so built as to adapt it to the conditions under which it is used. The speed and power of the windmill depend upon the velocity of the wind, and this also determines the amount of "sail" which the wind wheel needs to carry.

The wind wheel must also face the wind, so it is mounted on a revolving frame, or dome, which allows it to face in any direction. Some of the mills have rudders which enable them to adjust themselves, while others have to be turned by hand. An adjustment of the canvas, called the "sail," is also necessary to enable the mill to maintain a uniform speed and power with wind of varying velocity.

Holland especially is the land of the old-fash-

ioned windmill. Here for centuries it has been a faithful servant, grinding the corn and pumping the water from her low marshes over the

MODERN WINDMILL

dykes into the sea, and reclaiming thousands of acres from the grasp of Old Ocean.

The modern windmill is a modification of the machine already described. The wind wheel seldom exceeds six or eight feet in diameter.

and is made of slats radiating from the center, and fastened to a light iron frame. Each slat might be called a whip, though it more properly takes the place of the sail. These slats are so arranged as to react against the current which blows freely between them. Most of these mills are mounted upon light wooden or iron frames pyramidal in form, and from thirty to fifty feet in height. They are light structures, easily operated, and very useful in pumping water, turning grindstones, and operating other light machinery; but they do not afford sufficient power for heavy work like grinding grain. Many patterns of these mills are found in the agricultural districts of the central and western States.

THE STEAM ENGINE

Water wheels and windmills deal with the forces of nature directly as they are found. This, however, is not the case with the steam engine and the electric motor. Since steam is the form which water takes when heated to the boiling point, we employ the agent heat to prepare the water for the engine. The working of the engine depends upon the tendency of vapors and gases to fill all the space in which they are placed. If confined within a small space they exert great force, and this is employed in operating machinery.

When a drop of water becomes steam, it occu-

pies 1,700 times as much space as it did before. If this steam be heated to a temperature above the boiling point, it will occupy still more space. Take a small vial with a few drops of water in it, and tightly cork it and then proceed to boil the water, pointing the mouth of the vial away from you. In a few moments the cork will blow out with a sharp report, like that of a small pistol. If the cork can not be blown out, and you keep on heating the steam, the vial will burst. The steam engine is a device for using this power of steam in operating machinery.

The first attempt to make use of the power of steam is accredited to Hero of Alexandria, 130 B.C. Hero constructed a hollow copper ball, mounted upon two hollow trunnions which served for an axis. These trunnions were connected with a closed kettle and conveyed the steam to the ball. Upon opposite sides of the ball were tubes extending at right angles to the axis. Each tube had a small hole in the side at its farther end. These holes were so made that the escaping steam would react upon the air and thus move the machine. Thus you see that this device was very much like the old reaction water-mill, and they both employed the same principle, that of reaction of a current against the air. Hero's engine was merely a toy, but it called attention to the fact that steam might sometime be used as a motive power.

It seems that nothing was done with Hero's discovery for many centuries, as the next account of the steam engine bears the date of 1629 A.D. This account states that the engine consisted of a steam boiler in the shape of a woman's head, and the steam was forced from the mouth through a tube against the buckets of a wheel resembling the water motor in present use. The account further states that work was actually performed by this contrivance.

The beginnings which led to the steam engine in its present form are due to two Englishmen, Thomas Newcomen and James Watt. Newcomen's contrivance was a combination of the pressure of the air and the power of steam to work a steam-tight piston up and down in a cylinder. The steam forced the piston up, and was then condensed by having a stream of cold water turned on the cylinder. The pressure of the air then forced the piston down. The piston-rod was joined to a walking-beam which had its opposite end joined to the piston of a pump.

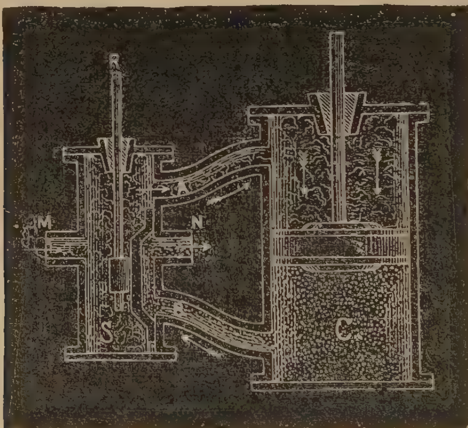
The valves necessary to keep the machine in motion had to be worked by hand, and a boy was engaged to attend to them. He had to make fourteen changes a minute, but it seems that he was able to study his machine and think while at work. One day he astonished his employers by leaving his engine and running off to play. The wonder was that the engine kept on working just

as well as when the boy was there. This boy's name was Humphrey Potter. When Humphrey's employer entered the engine room, he expected to find some of his workmen tending the valves. What was his surprise to discover that Humphrey had arranged a contrivance of sticks and strings so as to enable the walking-beam to open and close the valves; and his work was so well done that the engine became self-acting. Thus to a boy is due the credit for inventing one of the most important devices of the modern engine, that for automatically working the valves.

Watt so changed and improved Newcomen's machine that he is generally considered the inventor of the engine as it is to-day. He perfected his machine in 1769, and from that time the uses of the steam engine have constantly increased.

On first inspection, the modern steam engine appears to be a very complex machine, but further acquaintance soon convinces one that the parts are comparatively few and quite simple. The essential parts are the steam chest, cylinder, piston and piston rod, valves, connecting rod, shaft, fly wheel and governor. The piston fits into the cylinder steam-tight. The steam chest is a box on the top or side of the cylinder into which the steam is admitted when it comes from the boiler. Openings from this chest lead to

each end of the cylinder. A valve works back and forth over these openings so as to admit the steam first at one end and then at the other; there are also openings from the cylinder into the port, or escape pipe, through which the



STEAM CHEST AND CYLINDER

M, pipe from boiler. S, steam chest. R, eccentric rod working valve. A and B, pipes which conduct steam to the cylinder, C. N, escape pipe. The piston is in the middle of the cylinder, moving toward C.

steam escapes after being used. The valves are so arranged that when the passage is open from the steam chest to one end of the cylinder, that leading to the escape pipe is closed, and vice versa. By this arrangement the expansive force of the steam drives the piston back and forth

from one end of the cylinder to the other. By means of the connecting rod and crank this sliding motion is changed to a rotary motion in the shaft. A belt connects the fly wheel with the shafting that turns the machinery. The automatic action of the valves is secured by attachments to the shaft of the fly wheel. In some of the largest engines the fly wheel is toothed and fits to a pinion on the main shaft of the machinery.

Most stationary engines have but one piston and crank, but some very large ones have two. This does not alter the principle of action, however. In case of a double engine we simply have two engines working in one. The fly wheel is usually very heavy, so as to give uniformity and steadiness to the motion. The governor is an ingenious device for regulating the amount of steam supplied to the cylinder. This is so carefully adjusted that it responds to the slightest change in speed, and in this way keeps the motion uniform. The length of the cylinder varies from the diameter of the piston to twice that length.

The horse power is the unit for measuring the force exerted by the steam engine. A horse power is a force that will raise a weight of 33,000 pounds one foot in one minute. Hence the measure is estimated in foot-pounds. If an engine had a piston ten inches in diameter, its

area would be a little over 78.5 square inches. With a pressure of steam of 100 pounds to the square inch the piston would be driven with a force of 7,850 pounds. If the cylinder be one foot in length, this movement will represent 7,850 foot-pounds. Now if the movement is rapid enough to cause fifty revolutions of the fly wheel per minute, the force exerted by the engine will be equal to 7,850 foot-pounds multiplied by 100, the number of movements the piston makes, or 785,000 pounds. This divided by 33,000 will give the horse power. How much is it?

It is not strange that a machine which can exert so much force in so small a space should be modified in size, form, and pattern to meet all requirements. Hence we find engines of all sizes from the tiny toy to the monster that propels a steamship, and each is so delicately adjusted that the weight of a child's hand can control it.

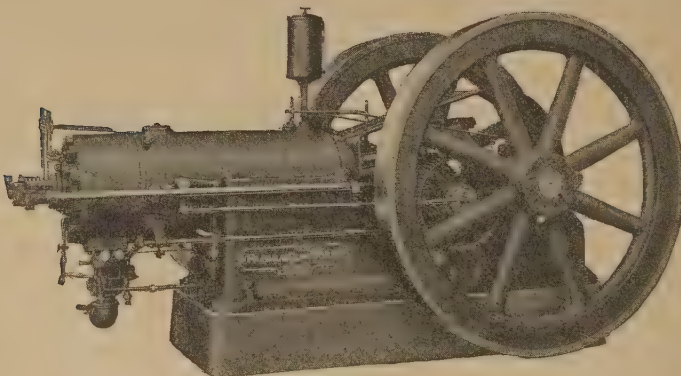
The boiler is an important part of the engine, as the success of the machine depends upon the quantity and quality of the steam furnished. There must be a constant pressure of sufficient strength to enable the engine to do its work, and the steam must be what engineers term "dry"; that is, free from moisture. As this condition can be attained only at a temperature considerably above the boiling point of water, such a

temperature must be maintained. The dome which you see on all boilers, is for the purpose of furnishing a chamber for dry steam. From this dome it passes to the steam chest, and thence to the cylinder.

Water must be supplied to the boiler as fast as it is taken up by the escaping steam. Should the water in the boiler get below the level of the pipes, or flues, as they are called, the intense heat would change the steam into oxygen and hydrogen gases, and set the hydrogen on fire. Whenever this happens, the boiler, building, and engineer are distributed about the town in which the accident occurs. Nearly all violent explosions of steam boilers are caused in this way. Most boilers are tubular, having a large number of flues passing through their entire length. The water surrounds these, and the fire passes through them. By this means the largest heated surface possible is presented to the water, and steam is made rapidly. By visiting any factory having a stationary engine, all the parts here described can be seen, except the valves which are inside the steam chest. It would be a pleasant and profitable excursion to visit an engine and study its working.

Besides steam engines, we now have numerous patterns of gas engines and air engines. The motive power of the gas engine is furnished by the explosion of gas in the cylinder, the explo-

sion being caused by an electric spark. Ordinary illuminating gas or that made from gasoline may furnish the power. These engines require neither boiler nor fire. They can also be run without the special attention of an engineer. The gasoline engine has been brought to a high degree of perfection, and engines of this type exceeding one



GASOLINE ENGINE

hundred horsepower are now found, but are used chiefly for propelling motor boats of large size. But these engines are equally capable of adaptation to conditions where high speed and light power are required. Different types of gasoline engines are constructed for operating light machinery for small motor boats, especially for propelling automobiles and aeroplanes, and the success of each of these is due largely to the perfection of this kind of an engine.

THE ELECTRIC MOTOR

The electric motor is another device for using power a long distance from its source. An electric motor is in no sense a generator of power. The electric current which constitutes the propelling force is generated either by water or steam power operating a machine called a dynamo. The current is transmitted to the motor by cables of either copper or aluminum wire. These cables are usually encased in rubber to prevent the escape of the electricity through the air. The motor consists of a powerful magnet surrounded by coils of wire so arranged that the electric current causes a rapid rotation of the magnet. Most motors of this class are constructed for light work, but those for operating electric railways are as powerful as large steam engines, sometimes having a hundred and even a thousand horse power.

The electric motor has two advantages over other motors. The current can be carried a long distance without losing much of its force, hence water power can be effectively used many miles from its location. The plant at Niagara, which has already been described, is the best illustration of this advantage on a large scale. The second advantage is in the even distribution of power over a large factory. Instead of long rows of shafting all connected with a large

engine, and which use a good deal of its power, the engine can be used to run a dynamo and the current be carried to various parts of the factory. The power thus goes directly from the electric motor to the machine, or group of machines to be operated. In this way power is saved, and the factory is spared the inconvenience of shutting down the entire plant for necessary repairs in any particular department.

Along with the invention and perfection of these motors have come many curious and wonderful machines by which we are able to use electricity to the best possible advantage. The effect of machinery upon the labor and manufactories of the world during the past fifty years has been such as to completely revolutionize nearly all branches of business, and is so great in other particulars that it is nearly if not quite impossible to estimate it. Someone has estimated that the work done by steam power alone is equal to that of one billion men, or more than three times the working population of the earth. Besides this there is the great power exerted by the water already in use, and not over one fifth of the water power of the world has been employed. Thousands of streams and waterfalls are still waiting their opportunity to send comfort and cheer to millions of people on the farms and in towns and villages.

It is by the wise use of these forces and inven-

tions that we are enabled to have so many pleasant things in our homes, keep ourselves comfortable with such good and tasteful clothing, and enjoy books and papers, and other pleasures which only a few years ago were considered as luxuries by the most wealthy. All useful inventions tend to make our necessities better and cheaper, and to give us more leisure to enjoy what is best and noblest in life.

We read in the Bible that the Lord made man in His own likeness, and gave him power over all the earth. By centuries of toil and study God has led us to discover more and more of the forces and secrets of nature. It would seem at first thought that all has been discovered, but each year brings to light some new power or property that is for the advantage of the people. The discoveries and inventions of the new century will undoubtedly far exceed, in both number and ingenuity, those of the century just closed. It would seem that the prophecy of one of our poets in his "Song of Steam" was about to be realized:—

Hurrah! hurrah! the waters o'er
  The mountain's steep decline;
Time—space—have yielded to my power;
  The world—the world is mine.

* * * * *

I carry the wealth and the lord of earth,
  The thoughts of his godlike mind;

The wind lags after my going forth,
  The lightning is left behind.

In the darksome depths of the fathomless mine
  My tireless arm doth play,
Where rocks never saw the sun decline,
  Or dawn of the glorious day.
I bring earth's glittering jewels up
  From the hidden caves below,
And make the fountain's granite cup
  With a crystal gush o'erflow.

I blow the bellows, I forge the steel,
  In all the shops of trade;
I hammer the ore, and turn the wheel
  Where all my arms of strength are made;
I manage the furnace, the mill, the mint,
  I carry, I spin, I weave;
And all my doings I put into print
  On every Saturday eve.

I have no muscles to weary, no breast to decay
  No bones to be "laid on the shelf,"
And soon I intend you shall go and play,
  While I manage this world myself.

GLASS

HISTORY

Glass is so commonly used and in such a great variety of ways, that one rarely ever stops to think of its history and of its immense value to man as a civilizing influence. Glass has a long and interesting history running back seven thousand years or more. Something of the history, manufacture and uses of glass will be given in this chapter.

If we were compelled to live in houses without glass windows, to use horns and gourds for drinking cups, and the skins of animals for bottles, it would require some time for us to become accustomed to our new surroundings. Yet there are countries where these conditions still exist, and they were common among all civilized nations until glass came into general use.

Glass comes from an Anglo-Saxon word, *glaes*, or the Latin *glesum*, each meaning amber, a substance found on the shores of the Baltic and North seas. Amber is a gum which has been for

ages buried in the sands of these shores, and is called fossilized. It often contains insects imbedded in it, in a perfect state of preservation. Amber is of a yellowish color, nearly transparent, and when polished is very beautiful. Glass is an artificial compound which in every particular except color closely resembles amber, hence its name.

The Roman writer, Pliny, tells us that ages ago some mariners landed on the coast of Palestine, on the banks of a small river, and placed some blocks of nitrum (soda) under their pots to keep them up from the fire, and that these blocks, being fused with the sand by the fire, produced a liquid and transparent stream. Pliny thinks this was the beginning of glass-making, but his story is not generally believed, as it would have been impossible for the heat of an open fire to fuse the material necessary to make glass. The story, however, shows an attempt by this celebrated writer to account for the origin of an art which had been brought to a good degree of perfection in his time.

Some one has said, "The history of glass-making would embrace a period commencing 5000 B.C. and running down to the very doors of to-day." But it is doubtful whether anyone has ever found the exact year when glass-making began. There is abundant evidence that this is one of the oldest of the arts. Paintings on the

walls of an Egyptian tomb dating from 3000 B.C. show Theban glass-blowers at work with nearly the same style of blow pipe as that used by those of the present day. In another tomb a necklace bead of crown glass was found inscribed with the name of a queen who reigned 1500 B.C.; and in the British Museum is a bottle of light blue glass on which are painted in yellow the name and titles of the Pharaoh of that time.

Many ornaments imitating the precious stones in color and beauty show that the Egyptians of this early date had brought the art of glass-making to a high degree of perfection. Historians tell us that glass was used by them for drinking vessels, mosaic work, sacred emblems and even coffins, and that all these articles attest their skill in workmanship and show a brilliancy of color that has scarcely been excelled in modern times.

The ruins of other ancient cities of the East also reveal many traces of glass-making. Among these are Nineveh, Sidon, and Tyre of the Bible, besides many of the cities of the Greeks. The collection taken from the island of Cyprus by General Cesnola, and now in the Metropolitan Museum in New York, is of special interest, and shows that the ancient Greeks had acquired great skill in the manufacture of glass. The collection contains over 1,700 pieces of plain and ornamental ware in great variety of form and

color, some of the vases and cups containing colors unknown at the present time.

The Venetians early became the best glass-workers of Europe, and during the 13th century and for several hundred years following, they were far in advance of other nations. The manufacture was confined to a small island near the city, and was liberally aided by the government. The workmen were also granted special privileges on account of the high degree of skill required in their art. It is probable that glass mirrors were first made here. Later the Bohemians attained superiority in the manufacture of white glass. From these countries the manufacture moved slowly westward, first into France, then into England, where records show that glass-makers were taxed as early as 1300 A.D.

The first mention of the use of glass for windows was about the close of the third century, and it is recorded that windows were first introduced into England in the latter part of the 7th century, and colored window glass is known to have been used in churches during the 8th century; but the general use of window glass was delayed for several hundred years. Even in the 16th century in England and the 17th in Scotland only the dwellings of the wealthy were provided with glass.

While glass has been made for centuries and by all civilized nations, the process of manufac-

ture and the materials used made it so expensive that it was regarded as a luxury, its use was limited and confined to the wealthy classes until within comparatively recent times.

The manufacture of glass was among the first industries attempted by the English colonists in America, but it is impossible to discover to what extent it was carried on before the Revolution. A history published in London, in 1776, mentions the erection of glass works at Jamestown, Va., but their completion was prevented by the Indian massacre of 1722. Another history of this settlement states that some of the inhabitants had been engaged in the manufacture of glass as early as 1615. Works were also constructed and operated near Salem, Mass., as early as 1639-40. The first mention of the glass industry in Pennsylvania is in a letter which William Penn wrote to the "Free Society of Traders" in 1683. In this letter he speaks of the glass works of the colony, but the location of these works has never been determined. Neither do we know what kind of glass they made.

After the United States had gained their independence, and were free from the restrictions which England had placed on their manufactures and commerce, there was increased activity in all lines of industry. Several large glass factories were soon in successful operation, and the number and size of such establishments have

been increased from year to year to meet the demands of the rapid development of the country. At first the two great centers of the industry were around Boston and Pittsburg, Penn., but now glass factories are found in many localities.

MANUFACTURE—I. MATERIAL

Glass is made by melting sand with lime, potash, soda, or oxide of lead at a great heat. Silica, which is the basis of sand, enters into all varieties of glass, and has more to do with determining the quality than any of the other ingredients. The purity of the ingredients and the proportion in which they are mixed also have much to do with the quality of the glass.

Sand may be said to form the basis of the glass, consequently its clearness depends largely upon the quality of this ingredient. The proportion of silica varies in different kinds of glass. In lead glass it is from 42 to 60 per cent; plate contains about 79 per cent, and window glass about 70 per cent. The amount of silica usually determines the degree of hardness, though other substances have some effect upon this quality. Lead tends to make glass soft, and lime makes it hard.

Nearly all the silica now used in the glass factories is in the form of sand, though until within the last fifty years that used for the best quali-

ties was produced by crushing and washing flint and quartz rock. This process was so expensive that it made the glass too costly for general use. Bohemian and a few other varieties of European glass are still made from silica obtained in this way, and the expense of Bohemian glass in this country restricts it to the homes of wealthy people.

The quality and purity of sand are of the greatest importance, especially in the manufacture of glass of high grade. The most searching examination, and careful tests are made to determine the nature and extent of any impurities which the sand may contain. These impurities are commonly oxide of iron (iron rust) alumina in the form of clay, loam, gravel, and decaying animal or vegetable matter. Most of these can be removed by burning and washing, but the iron, which is the most troublesome of all, can be removed only by the use of chemicals. Iron is the most dreaded because it discolors the glass and destroys its transparency. A proportion greater than one half of one per cent renders the sand worthless for even the poorest quality of glass, and for the best qualities it must be entirely free from iron.

The microscope affords the best means of detecting the impurities in sand, as a skillful observer can detect them by the shape of the particles. Still the only sure test, as with many

other things, is by actual use, as sand from different localities having no apparent difference in quality will often produce different grades of glass. A yellow sand will sometimes make a clearer glass than one perfectly white, and no test except actual use will enable the manufacturer to determine this fact.

Much of the sand used in glass-making occurs in the form of sandstone, and is quarried in blocks. The stone soon crumbles on exposure to the air, or it can be easily crushed. Glass of an inferior quality is frequently made from sand found near the mouths of rivers, or on the seashore. This was especially true of the glass made by the ancients. Probably the location of many of their factories was determined by deposits of sand, and the advantages of seaport towns in giving a market for their wares.

The most noted of these ancient sand deposits was that of the River Belus near Mount Carmel of Biblical fame. Glass was made in great quantities from this sand by the Sidonians, ancient Greeks, and, later, by the Venetians. Every country of Europe in which glass is made has deposits of sand suitable for the purpose, but American sand is considered superior to all other. Some of the best deposits in this country are in Berkshire County, Mass.; Juniata County, Penn.; Hancock County, W. Va.; the valley of the Fox River, in Illinois; and at Crystal City,

Mo. Large deposits are also found in many other localities.

Most of the other ingredients of glass are known as alkalies. Any good chemistry will tell you that an alkali is one of a class of substances which turn vegetable yellows brown, form soaps when mixed with fats and oils, and salts when combined with acids. In general, alkalies have a bitter, pungent taste, and are exceedingly corrosive to the flesh. Soda, potash, ammonia, and lime are some of those in most common use. All of these except lime can be obtained from vegetable products, as potash from wood ashes, soda from the ashes of seaweed, and ammonia from decaying vegetable matter. Lime occurs in limestone, and is extracted by burning.

Lime, next to silica, is the most important ingredient of glass. It is found in nearly all kinds, with the exception of that in which lead is used, and this variety sometimes contains a small quantity. Lime imparts brilliancy and hardness to glass, and care must be taken to preserve the proper proportion, as too much will make the glass so brittle that it is not durable. The use of lime may be said to be one of the modern improvements in glass-making, and its introduction has greatly improved the quality of the product.

Soda was undoubtedly the first alkali used in the manufacture of glass, as large quantities of

it in the form of sulphate and carbonate are found on the banks of the Nile. At a later date it was obtained by leaching the ashes of seaweed and evaporating the lye. At present it is made wholly from common salt, of which it is an important ingredient. The great soda works of the world are at Lancashire, England, and most of that used in the glass factories of the United States is brought from there.

The general use of potash is of comparatively recent date, though it has probably been used to a small extent for several centuries. Potash is obtained from a mineral called carnallite, which is a compound of potash and magnesium, and from leaching wood ashes and evaporating the lye. The most of that obtained from wood now comes from Canada.

The compound of lead used in glass is an oxide, and is usually known as red lead on account of its color. It is the same lead as is used for the basis of red paint. Lead is used in those varieties of glass which require perfect transparency and a brilliant luster. While it makes a beautiful glass, it also makes it so soft that it is easily scratched, and needs to be handled with care.

II. THE FACTORY

The location of a glass factory is largely determined by the presence of sand and fuel, as the

expense of freighting these is very heavy. When the location is decided upon, the plan of the factory must be determined. This will depend upon the product desired, for each factory is constructed for its special work, and can not do any

A GLASS FACTORY

other. There are at least six kinds of glass, each requiring a special building and furnace for its production. These are bottle, crown, sheet, window, plate, flint, and colored glass. The general principle upon which all glass furnaces are constructed is the same; viz., to secure a great degree of heat from such fuel as will not affect

the material to be melted. For this reason gas is the only fuel that can be successfully used.

The furnace occupies the center of the factory. Its form depends upon the plan for melting. If pots are to be used, the shape is usually conical, and a shelf is placed around the walls for the pots to rest upon. If the melting is to be done in a tank, the furnace is rectangular, and does not have any shelf. We will first look at the furnace with pots.

The furnace is so constructed as to allow each pot to be heated by a separate flame. In front of each pot is an opening called the "work hole," through which the melted glass is taken out and the new material put in. The furnace gradually tapers to a huge chimney whose mouth projects a few feet above the roof of the factory. Some factories, however, construct quite tall chimneys, as they give a stronger draft, and economize the use of fuel.

Under the furnace is a passage, called the "cave," which catches the cinders and other refuse from the fire, and also allows a free passage of air so as to prevent the walls of the fire pot from being damaged by the intense heat. This cave usually has four passages arranged at right angles to each other, and meeting directly under the fire. This always assures a current of air, whatever direction the wind way take. Furnaces for making flint glass do not have any

flame in the center, but each pot has its separate flame and flue.

The tank furnace differs from that described in that it has a large tank in which the glass is melted and from which it is drawn. The work holes are provided with tubes which lead to the bottom of the tank, and the glass is drawn out through them. The bottom of the tank inclines toward the end, where the work holes are, and, as the glass becomes thoroughly melted, it runs down this incline. The material is supplied at the opposite end of the tank, so there is no interruption by the putting in of new material. Tank furnaces are much more convenient and economical than pot furnaces, and are used in most factories which make bottles, window glass, and plate glass. All furnaces are lined with the best quality of fire brick.

Besides the melting furnace, each factory must be supplied with several annealing furnaces, for tempering the glass, one for baking the raw material, and, in window-glass factories, furnaces for flattening the cylinders, as you will see a little further on.

Besides the building containing the furnaces, each factory must have a machine shop and blacksmith shop. If coal is used for fuel, a gas plant is also necessary, as the coal must be converted into gas before it can be used in the furnace. A large store house is another necessary

part of the plant. These buildings usually present anything but an attractive appearance, as they are simply for the purpose of protecting the workmen and machinery. Occasionally, however, substantial brick buildings are found.

The leading States in the manufacture of glass are New Jersey, New York, Pennsylvania, Indiana, Ohio, and Illinois. Pittsburg, Penn., is the great center of the industry, and the discovery of natural gas in Indiana has caused many factories to locate in the gas belt within the past few years, since this gas furnishes by far the cheapest fuel that can be obtained.

The manufacture of the pots for the furnaces is the most tedious and exacting process in glass-making. The material used is a mixture of raw and burned fire clay. This must be prepared and mixed with the greatest care. No machine has yet been invented that will do the work in a satisfactory manner. The mixing is done by treading the clay with bare feet at least once a day for four weeks, and the quality is improved by a longer kneading process.

The construction of the pots is also entirely by hand. The bottom is about forty inches in diameter, and four inches thick. The pots are built very slowly; only a little clay is added each day, and it takes nearly six weeks to complete a pot. During the construction the pots are kept covered with wet cloths to prevent too rapid

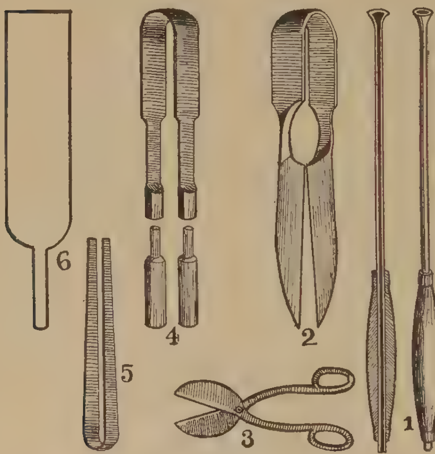
drying. Particular attention is also given to the temperature and humidity of the work room, as even a slight change in these conditions may cause the pot to crack. After completion the pot must dry slowly for several weeks before it is ready for the furnace. Before placing the pots in the furnace they are all cautiously tried in a small furnace made specially for the purpose. The pot is here brought to a white heat, and, if no crack is discovered, is placed in the melting furnace while hot. These pots vary in size, having capacities ranging from 2,000 to 4,000 pounds. Some of them are open at the top, and resemble a huge flower pot in shape. Others have a dome-shaped top with a hole in one side of it. This pattern is used in furnaces for making flint glass.

The durability of the pots is very uncertain. Some will last for months, while others crack, and have to be removed within a few days. The removal of an old pot and placing a new one while the furnace is in operation is a difficult task, and often attended with considerable danger.

III. WORKING

There are three methods of glass-working: casting, pressing, and blowing. And by these all the varieties of glass are made. The glass-blower uses but few tools, and these are of very

simple structure. In fact, they are changed but little from those used in the beginning of the industry, nearly 5,000 years ago. In no other art does the quality of the product depend upon the skill and care of the workman to the extent that it does in glass-making, for in this art the workman takes the place of the machine.



GLASSMAKER'S TOOLS

1, blowpipe. 2, pucellas. 3, shears. 4, pucellas with wooden blades. 5, spring tongs. 6, battledore.

The first tool in importance is the blowpipe.

This is an iron tube between four and five feet long, a little larger at the mouth end than at the other, and having a bore from one-fourth to one inch in diameter. This is the long hand which reaches into the furnace and gathers the melted glass for working; it is also the tube through which the workman forces air into the center of the glass to expand it into the desired form. A solid rod of iron, called the punty, is used to receive the article upon its end when freed

from the pipe. A little red-hot lump of glass is usually attached to the punty, and this sticks to the article taken from the pipe. Spring tongs, resembling sugar tongs, are used to pick up pieces of melted glass; and a heavier pair, called the pucellas, and furnished with broad, blunt blades, serve to shape articles when pressed against the glass by the workman holding the pucellas in one hand and rolling the object with the other, while the pipe rests on the arms of a chair made for the purpose. Shears are necessary to cut the glass, and two styles of these are used. A wooden tool shaped like an old-fashioned paddle, and called the battledore, is used to flatten the glass by beating when necessary. Compasses, calipers, and measuring rods are also at hand, and the carriers have an iron rod forked at one end which they use in carrying the articles to the annealing oven.

IV. MELTING

The materials, which have already been described, are mixed in a long box closely resembling a baker's kneading trough on wheels. The mixture, known as the "batch," is of a light gray color, and has the appearance of a medium grade of sand. Pieces of glass, called "cullet," are scattered through the mixture before it is placed in the furnace. The cullet serves two purposes; it uses up the waste glass

which accumulates in the factory, and aids in fusing the mixture.

If the furnace is one in which pots are used, the batch must first be heated in a small furnace, as previously mentioned. If it is a tank furnace, the batch is usually fed in direct as fast as it is needed to keep up the supply of melted glass. The batch usually requires from twenty to twenty-four hours to melt, and two or three hours to free itself from impurities. These rise to the surface, and are removed by skimming, very much as one would skim sugar when it is boiling. After it is purified, the melted glass is allowed to cool a little to make it viscid before it is taken from the furnace for the blower.

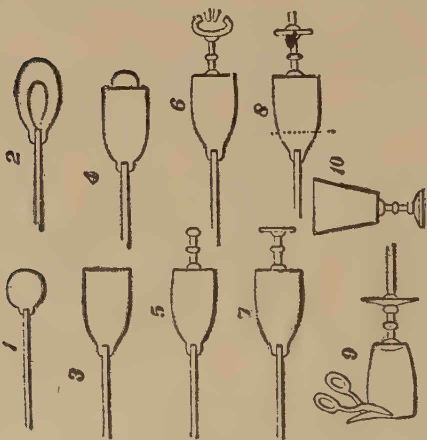
Most of our ordinary table ware is made by pressing. The press consists of a mold and a plunger worked by a lever. The mold is of iron, and contains the design and ornamentation of the article to be made. The workman who operates the mold has two assistants; one, called the gatherer, places his plowpipe in the tank and brings out a quantity of melted glass on the end of it; from this he cuts with shears enough to make the article. This drops into the mold and is immediately pressed into shape by the plunger. As a mistake in the quantity would spoil the article, the gatherer needs to exercise great care to cut just enough glass to fill the mold. As soon as the plunger has done its work, the mold

is opened by the second assistant, who is a boy, and the article taken out. The boy carries it to the polisher, and, when he has polished it, to the annealing oven. Some articles, like goblets, are made in two parts and put together by a workman after leaving the mold. In case of a goblet the bowl is made in one press and the standard in another.

Some of the most expensive table ware is made wholly by blowing. Most vases and other ornamental articles are also made by the same process. By following the making of a wine glass we can see the amount of skilled labor necessary to produce this kind of ware, and also understand why blown glass is so expensive.

The workman gathers on his blowpipe the necessary amount of glass (1). He then rolls it on a small slanting table, called the marver, making a bulb nearly oval in shape (2). He then flattens the end of this with his battledore (3). The next step is to attach a lump of glass to the center of the flattened surface (4). Sitting in his chair, which has inclined arms for the blowpipe to roll on, the workman takes his pucellas and shapes the lump as shown in (5). This forms the stem, or standard. A globe is now attached to the bottom of the standard and shaped into a disk which forms the bottom (6). A punty tipped with a small knob of hot glass is now fastened to the foot of the wine glass (7),

and it is severed from the blowpipe (8). The top of the cup is trimmed with shears (9), after which it is reheated and finished (10), making in all ten processes through which the wine glass must pass before it reaches the annealing oven.

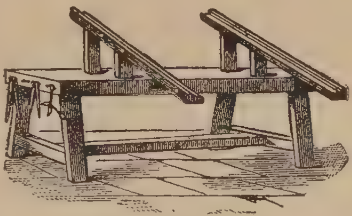


PROCESS OF MAKING A WINE GLASS

But you may ask, "What is the annealing oven?" Well, we will tell you. If the glass is suddenly cooled, it becomes very brittle, and will often crack and fall to pieces without any apparent cause, as lamp chimneys of a poor quality sometimes do. To prevent this all articles pass directly from the blowers to the annealing oven, where they are cooled very slowly. The process of annealing is carried on either by allowing the ovens to cool gradually, or by having an endless platform which carries the articles through all degrees of temperature as they pass through the oven. As the first plan is less expensive it is generally employed for all common purposes.

By either process the glass is cooled so slowly that it becomes well tempered.

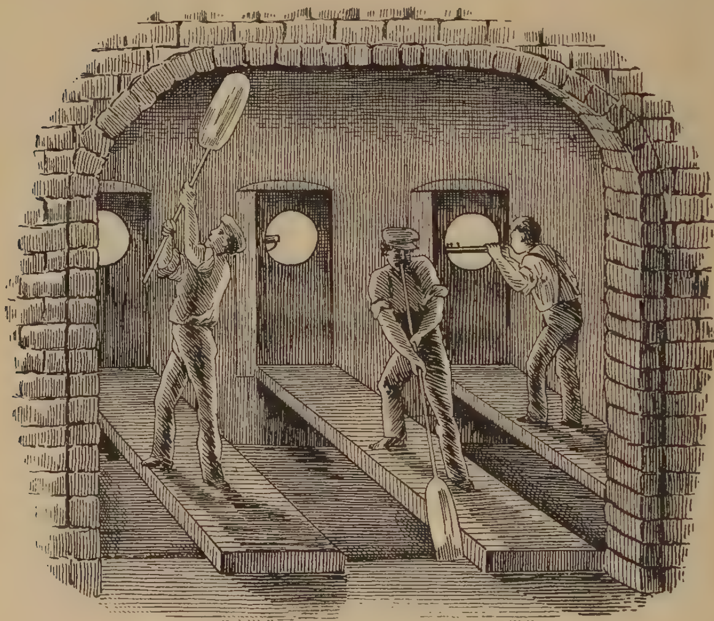
The manufacture of window glass forms an industry by itself, and requires blowers of great strength, as the quantity of glass worked at one time is much greater than in the blowing of small articles. The gatherer gathers with great care the amount necessary to form a cylinder, about twenty pounds, and passes it to the blower. To gather this quantity requires several dips of the pipe, and each addition must be placed on the end of the blowpipe evenly, and so that the mass will not contain any air bubbles. The blower proceeds to work this mass into a cylinder by blowing into the pipe, and at the same time swinging it and rolling it rapidly in his hands. The mass first becomes pear-shaped; the workman now raises it over his head, and continues the process until this form is changed to that of a cylinder, when it is again lowered and swung to lengthen it.



GLASSMAKER'S CHAIR

When completed, such a cylinder will be about forty-five inches long and a foot in diameter. It is closed at both ends. If the walls are thin, the blower opens the end opposite the pipe by blow-

ing into the cylinder, placing his thumb over the pipe, and at the same time holding the end of the cylinder toward the fire. As the heated air expands, the cylinder bursts open at the point



BLOWING CYLINDER GLASS

where the glass is the hottest. The opened end is usually trimmed with shears, though it may be evened by working it at the fire. This process, however, is attended with loss of time and glass. The cylinder is next cut from the blowpipe, laid upon the flattening table, and cut open.

This is done either with a red-hot iron, or a diamond on a long handle. A rule is run into the cylinder, and the diamond marks it. A cold iron is then laid over the scratch, and the cylinder cracks open.

The opened cylinder is next placed in the flattening oven with the split side up. Here additional heat soon flattens it to a wavy surface. A workman known as the "flattener," now applies a tool called the "polissoir," which is simply an iron rod with a block of wood fastened to each end. With this he rubs the wavy sheet into a flat surface. The sheet is now taken to the coolest part of the furnace, where it is removed to the cooling stone. As soon as it is rigid enough to be moved, it is taken from this stone to the annealing chamber. This corresponds to the annealing oven used for small ware. The hearth of the laying-in furnace, as this chamber is sometimes called, is circular, and is divided into a number of sectors, by fire-clay bridges. As the hearth revolves, the different sectors pass through as many compartments of the furnace as there are sectors. Each of these compartments can be heated to any required temperature, and the annealing is finished by passing the glass through a chamber where it is slowly cooled. After annealing, the glass is cut into various sizes, sorted, and packed for shipment.

Someone has said, "A window is something to be seen through, and not to be seen." That this condition may be realized great skill is necessary on part of the blower, for the even thickness of the glass and freedom from spots, or air bubbles, are wholly due to his manipulation while blowing. The blowers stand on a narrow platform which bridges a pit about ten feet deep. This gives ample room for the manipulation of their work.

Plate is by far the most expensive, and most desirable form of window glass. Its brilliancy is due to the purity of the material employed, and the care taken in its manufacture. It is made by what is known as the casting process. The melted glass is poured upon a large casting table which has a rim around its edges. An iron roller rests upon this rim, and passes quickly over the glass and flattens it into a sheet, which is at once removed to the annealing oven. After annealing, the plate is ground down and polished. This last process gives plate glass its brilliant luster. Unpolished, or rough plate is used for sky-lights. Plate glass is used for large windows and large mirrors. It needs to be very thick when used in large panes, to enable it to withstand the strain of high winds, consequently it is very heavy. It is shipped by placing single panes in crates made especially for them. In handling, care must be taken to keep the pane on one edge, as,

should it be laid on the side, it would break of its own weight.

A peculiar form of plate, known as wire glass, is manufactured by a few firms for basement windows. This glass has wire netting imbedded in it, and is not easily broken.

The first glass bottles were valued as ornaments, rather than for their utility. However the place of the glass bottle in our everyday life has become so important that merchants and customers alike would be placed to the greatest inconvenience were their manufacture to cease, and were we compelled to find a substitute for them.

Bottle making, an extensive industry, in the United States is carried on largely in some parts of New Jersey, around Philadelphia, and in the valley of the Fox River, Illinois. Three grades of bottle glass are known to the trade. The ordinary green glass, which is obtained by mixing about thirty-eight parts soda and twenty parts marble dust with every one hundred parts of sand; the amber glass, which is of about the same composition as the green, except that it contains a little ground coke or black lead as coloring matter; and flint glass, which is of the finest quality, and has about the same composition as the green, but is made of pure material, with a bleaching agent added to make it colorless. If blue bottles are desired, a little peroxide

of cobalt is added to give the glass the necessary color.

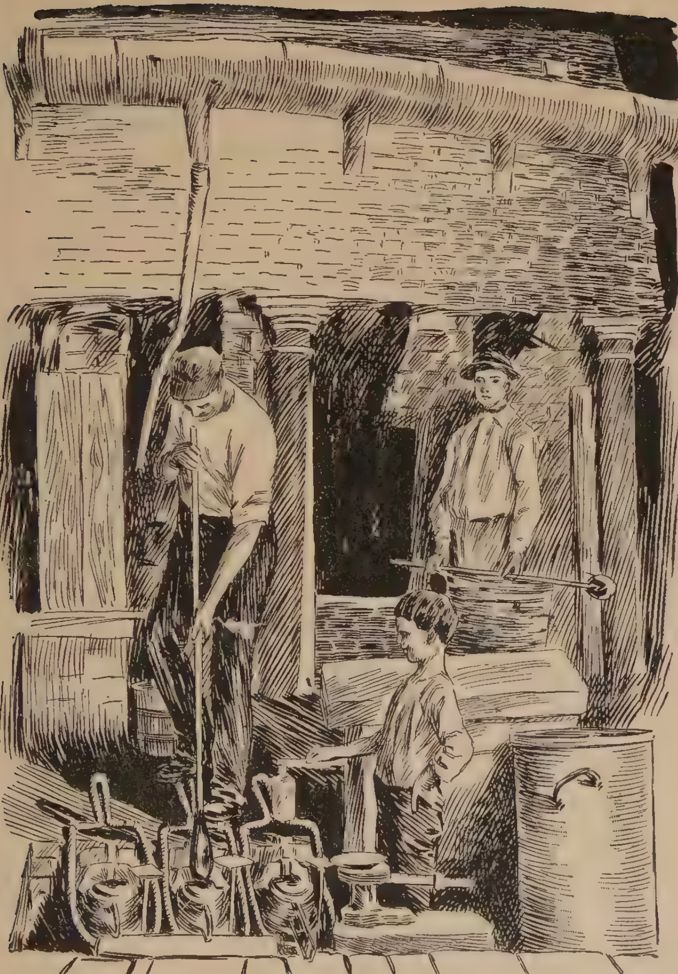
Most of the modern bottle factories have tank furnaces, and the blowers are stationed on platforms around the gathering holes. Each blower is provided with a small marver and a mold. His assistants consist of a gatherer and a boy to work the mold. As the gatherer hands him the blowpipe with the necessary quantity of glass on it to form a bottle, he gives it a roll on the marver, and then blows into the pipe and enlarges the glass to a small bulb. He now places the bulb in the mold so that the end of the blowpipe will just shut into its mouth, and gives a vigorous blow. This forces the glass to fill the mold and take every impression that has been wrought into its surface. The attendant opens the mold and takes out the bottle which is taken by another boy to a workman who finishes the neck. When this is done, the bottle is ready to be taken to the annealing oven by a third boy. These ovens are closed at the end of each day's work, and allowed to cool slowly. When they are opened, the ware is taken to a storeroom, sorted, and packed for shipment. The sorting is for the purpose of throwing out any that may be defective, and those who do the work exhibit great skill in detecting the imperfect bottles. Bottles of ordinary size, such as pint and quart bottles, are turned out very rapidly, some of the

MARVERING

most skillful blowers making them at the rate of more than a bottle a minute.

A bottle-making machine has been invented and is taking the place of hand labor in some of the largest factories. The machine is a complicated affair and the secret of its success has been carefully guarded by the inventors. It is used in connection with the tank pattern of furnace, and is so constructed that the molten glass is automatically forced into the mold and fashioned into a bottle. In factories where these machines are used the raw material for making the glass enters the furnace at one end and the finished bottle comes out at the other. A single machine can produce as many bottles as a number of the most skilful blowers; therefore the use of the machines lowers the cost of manufacture.

The typical mixture for cut glass would be to every 100 parts of fine white sand add 10 parts burned lime, 40 parts carbonate of soda, and 40 parts red lead. The first three ingredients form ordinary glass. The object of the lead is to increase the weight, and consequently the refracting power and brilliancy of the product. The best lead glass for domestic use is three or four times as heavy as water. The material for cut glass must be thoroughly mixed. This is done by feeding the ingredients into the upper end of a slowly revolving hopper, having an inclined axis. A dainty pink powder falls into



PLACING THE BOTTLE IN THE MOLD

the receiving bin, and heat transforms this into the brilliant glass for cutting.

All articles for treatment in the atelier, as the workshop of the glass-cutter is called, are blown, as working in the air increases the brilliancy of the glass. In the atelier one finds several processes going on side by side.

A blank is a perfectly plain, simple, heavy bottle, and its future value depends largely upon the cutting. This involves four processes: First, cutting the design. This is usually termed "roughing," and the wheel upon which it is done is called the "roughing wheel." This is a plain iron wheel with sharp edges, and mounted on a horizontal axis. The face of the wheel is about seven-eighths of an inch broad; this is kept supplied with coarse sand and water, which constantly drip from a hopper above.

If a design is to be cut on the bottom, the workman holds the blank upon the wheel so as to make the first cut through the center. Then, turning the blank a few degrees, another line is cut in the same way, and so on until the design is completed. The curved sides of a carafe, or water bottle, are sometimes outlined with a few guide lines, but most of the designs are made directly from the eye without pattern, and bear strong testimony to the skill of the cutter.

The second process is smoothing, and consists of grinding the articles on wheels of sandstone

of a peculiar quality. The wheels are so shaped as to have the sharp edge in the middle. A tiny stream of water constantly falls upon the wheel whose action smooths the edges and surfaces formed by the roughing wheel.

THE GLASS-CUTTER AT HIS WHEEL

The third process is polishing, and is effected by wooden wheels supplied with pumice stone. The polishing gives a fine finish to the cut surfaces, and adds much to the brilliancy of the facets.

The fourth and last process is brushing. The

brush is made of spun glass, and is applied in the form of a wheel. This cleans the cuttings, and leaves the article ready to be washed and placed on sale.

The beauty of cut glass is due to its great brilliancy and refractive power. These effects are best secured by placing the articles upon, or in front of, a mirror. In stores which deal in cut glass we always find it so placed. Some large stores even have a room specially fitted up for this purpose. A visit to such a room gives one an excellent idea of the beauties of cut glass, and is well worth the time and effort expended. Cut glass is very expensive and very highly prized. Within the past few years it has taken the place of silverware as a table ornament in many fashionable and wealthy homes.

Engraving is another method of ornamenting glassware which depends for its success almost entirely on the skill of the operator. The tool used is a small copper wheel, varying from three inches in diameter to a tiny point. The wheel is mounted on a horizontal axis and revolves very rapidly. The surface is supplied with a mixture of emery and oil which constitutes the cutting agent. The operator holds the glass under the wheel, and is guided largely by the sense of touch. Names, initials, vines, birds, plain bands, and a great variety of other ornaments are made in this way. This style of ornament is usually

placed on articles of thin glass of excellent quality, and is not as expensive as cutting.

The sand blast is another means of engraving glass. The design is cut through plates of rubber which protect the glass except where the pattern is exposed. Etching by acid is also

MAKING SPECTACLE-LENSES

another method of ornamenting. In this process only the design is exposed, the other parts of the surface being covered with wax, which the acid will not destroy.

The manufacture of lenses constitutes another very important use of glass. Without glass we should not have the microscope or telescope,

and, what is more important than both these, no spectacles. By means of the miscroscope and telescope many important scientific discoveries have been made and perfected, but by means of spectacles, many who would otherwise be practically blind, have had their sight restored. Lenses were first applied to spectacles sometime in the latter part of the 13th century, but the exact date is not known. The microscope came into use about 1590, and Galileo made his famous discoveries with his telescope in 1610, though telescopes had been made in Holland two years before.

Glass for lenses needs to be free from impurities, perfectly transparent, and of a high refractive power. Flint glass for large lenses is made by placing the ingredients in pots of the purest clay. When the batch is fused, it is stirred for about three hours, during which time the temperature is gradually lowered. This prevents the lead from settling and making layers of different density as the mass cools. When the glass becomes too viscid to stir, the pot is sealed to prevent any air from entering, and the furnace is left to cool, which requires from eight to ten days. The furnace is then taken down and the glass removed. The glass is found to be cracked and broken into irregular lumps. Each lump is examined, and if found perfect or nearly so, it is ground into a lens. After grinding, the lens is

annealed and then further examined for imperfections. If found, they must be ground out and the disk annealed again. When perfected as far as possible in the factory, the lens is sent to the optician, who proceeds to test it for unequal density. If it withstands this last test, the surface is still further finished and polished, when the lens is ready for the telescope.

Some of these lenses for telescopes are very large, and exceedingly difficult to construct. The two largest telescopes now in use are in the United States; the largest near Lake Geneva, Wisconsin, and belonging to the University of Chicago, and the other at Lick Observatory in California. The first-mentioned telescope has a lens nearly 40 inches in diameter, and a tube 64 feet long. That at Lick Observatory has a lens 36 inches in diameter, and a tube 57½ feet long. It is gratifying to know that the most successful makers of large lenses are also citizens of the United States. Messrs. Alvan Clark and Sons, of Cambridge, Mass., have made the lenses for all the large telescopes in America, and for some of the largest in Europe.

The effect of such a telescope is equivalent to that of enlarging the eye until the pupil would have a diameter equal to the lens. By the use of one of the instruments the astronomer can gaze for millions of miles into space and there

discover heavenly bodies whose existence was before unknown.

The manufacture of colored glass forms a separate industry, though it has many features in common with the manufacture of transparent varieties. The various colors are produced by adding oxides of certain metals to the batch. Oxide of gold gives a ruby red, oxide of copper or zinc, blue, antimony gives a soft white enamel, and tin the hard white enamel seen in watch dials, etc. The variegated effects in ornamental ware are produced by the skill of the workman in blending these tints and colors as he makes the object. A very little colored glass placed in the metal from which a vase or similar object is to be made before blowing, expands with the glass into broad bands or other designs according to the intent of the blower. Beautiful figures are often made and then forced into the vessel to be ornamented. Colored windows are usually mosaics of different colored glass so cut and fitted as to produce the picture. Some of these windows have become celebrated as genuine works of art. Especially is this true of the windows of many of the great cathedrals of the Old World. Colored glass is sometimes cut into small pieces and used in ornamental mosaic work in public buildings. As it never loses its color and does not decay, it is a desirable mate-

rial for ornamental purposes wherever it can be used.

There are many curiosities connected with glass-making that are interesting to notice. Spun glass is made by melting a glass rod in a blow-pipe flame and drawing the melted thread over a rapidly revolving wheel several feet in diameter. At the Libbey Glass Works at the Columbian Exposition, in 1893, glass was spun in this way and woven into cloth for a dress for the Queen Regent of Spain. The warp was white silk, and the glass constituted the woof. The weaving was done on a hand loom.

Glass tubing is made by blowing a bubble into the metal, and then two workmen stretching this as rapidly as possible. The size of the tubing depends largely upon the rapidity of the process. The small tubes used in making thermometers are made by the most rapid process. The iridescence seen in frost work on cards, and the imitation of sea-foam seen surrounding toy glass ships, are made of fine flakes of glass produced by blowing the metal until it bursts.

"The ease with which glass can take any desired shape; its cheapness, owing to the material from which it is made; its durability, especially resistance to decomposition by acids and other corrosive substances; and its transparency, render glass one of the most useful of substances. Its brittleness is almost the only draw-

back to its good qualities. It is now so common, and in such universal use, that civilized nations would not know how to order their affairs were it removed from the possibility of ordinary use."

Glass manufacturing is one of the very important industries of the United States.

LEATHER

AS YOU probably know, all leather is made from the skins of animals by a process called tanning or tawing, which is but a modified form of tanning. Physiology tells us that the skin consists of two layers, the dermis, or true skin, and the epidermis, or surface skin. The dermis is made up of fibers compactly interlaced and woven together. These fibers contain a large proportion of the substance like that from which glue and gelatin are made when it is boiled. The skins of animals do not differ in this particular from that of the human system, and it is the der-

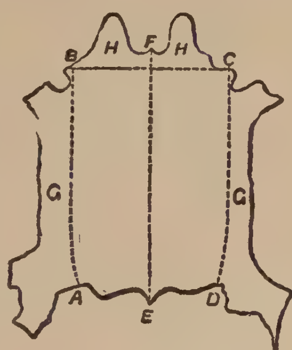
mis of these skins that is changed into leather by tanning. Many years ago it was discovered that the barks of certain trees, such as oak and hemlock, and the leaves of other plants, like the sumach, contain substances which would unite with the gelatin in the fiber of the skin, and, in the course of time, change it into a hard, tough substance. This, in the main, is the process of tanning.

When the hides reach the tannery, they are usually packed in salt to prevent decay. The first step is to clean and soften them. This requires several days' soaking in water, followed by a thorough washing. They are next placed in a strong solution of lime for a number of days to loosen the hair, so it can be easily removed. This is done by a process called beaming. The workman places the hide on a bench having a round upper surface, and two legs about three feet high at one end, while the other end rests upon the floor. He now takes a knife having a dull edge, and the blade shaped to fit the surface of the bench, and with this proceeds to scrape off the hair. The hides are again thoroughly washed, and then placed in a solution known as the "bate," which prepares them for the tanning process.

The bark is ground and steeped, and the hides are soaked in the liquor thus obtained. Sometimes the hides are packed in vats with layers of

bark between them, in addition to the solution. The length of time required to tan the skin depends upon its thickness and upon the quality and kind of leather desired. Continuous study of the process, and improvements in the material and machinery used, have succeeded in improving the quality of leather, as well as in shortening the time required for tanning, and also reducing the price of the product.

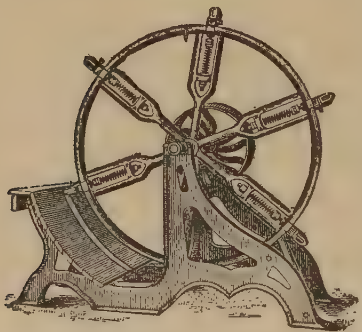
But little change has been made in the process of tanning, as the chemical action on the skins must be the same that it was at the beginning of the art. The changes have been in the methods of working, and these have been brought about by the invention of machines for doing many parts of the work which were formerly performed by hand labor. Several of these machines consist of sets of rolls and polishing wheels, and are used in finishing the leather. By their use what before required hours of hard work, can now be accomplished in a few minutes.



HOW A HIDE IS CUT

Sole leather is made from the backs and shoulders of the hides of cattle and buffalo, and requires a longer time to tan than the thinner

skins used for the uppers of shoes. These are usually made from the hides of calves, young cattle, and a small breed of cattle common in Russia, India, and Africa. All light and spongy leather, like morocco and its imitations, are made from the skins of sheep and goats. Alligator skins were first tanned in Louisiana about 1855, and since that time the manufacture of this sort of leather has developed into quite an industry. Russia and Cordovan are varieties which originated in Europe, but are now manufactured in this country. The so-called morocco is a modification and improvement of the Cordovan, and is extensively used in bookbinding and the covering of cases.



POLISHING MACHINE

There are three kinds of leather, based on the methods of manufacture. Tanned leather is made by combining the gelatin of the skin with the tannin of the barks of trees. Tawed leather is made by combining the gelatin with the salts of certain minerals. Shamoyed leather is made by combining the gelatin with oils and fatty substances. The tawed and shamoyed are used for

gloves, clothing, and various domestic purposes. Some of the finer qualities are finished in highly ornamental colors, but the red tanned leather is the oldest in this country and takes precedence over all other varieties.

The location of tanneries has been determined largely by the distribution of tanning materials. Naturally the centers of the leather trade have followed the tanneries. Hemlock bark is found quite generally in Pennsylvania, and the States along the Alleghany range to the north of it, in Canada, and in some sections around the Great Lakes. New York is the largest leather market in the United States, with Boston next in importance. Philadelphia, Baltimore, and Chicago are also important centers. New York, Pennsylvania, and Massachusetts are the leading States in the manufacture of leather, while Maine, Illinois, and Ohio have the industry well developed.

BOOTS AND SHOES

SHOES are undoubtedly one of the oldest articles of dress. The first shoes were mere sandals for the protection of the foot. But even in so simple an article as this we find national taste displayed at an early date. The Egyptians used sandals of palm leaves and leather, while the Hebrews preferred linen or even wood. These were fastened to the foot by thongs, or cords passing over the ball of the foot and around the ankle. The men among the ancient Greeks went bare-footed, but the women early began to wear a covering for the foot, and from this beginning the custom became general. The Romans seem to have taken the custom from the Greeks, and when the shoe was once introduced into these nations, a multiplicity of styles soon followed.

Among the royal households and aristocracy

the shoe early became a distinguished article of dress. We read that in the days of Richard II., of England, the points at the toe had increased to such length that they reached the knee, to which they were attached by gold or silver chains. The upper parts were cut to imitate the windows of a church, and the whole shoe was very conspicuous. For nearly three hundred years did the clergy, the popes, and public officers strive to abolish this extravagant, and what would seem to be foolish, custom. Finally, by act of Parliament in about the middle of the fifteenth century, shoemakers were prohibited from making for the unprivileged classes any shoes with points more than two inches long. But it seems that the shoemakers of that day were equal to the emergency which often confronts their modern representatives. They must have something for style, and when they were prohibited from extending the toe lengthwise, they began to increase its width, and we find in the days of Queen Mary another decree restricting the width of the toe to six inches.

The shoe of the sixteenth century in Europe, and among the court classes, was an elaborate article of leather and cloth, often ornamented with gold, silver, and jewels. Among all civilized nations the shoe is a badge of distinction. But the most strange and unnatural shoe is that of the Chinese lady of rank. From infancy the

growth of her feet has been checked by bandages at the expense of extreme suffering and inconvenience, for the higher she is in rank the smaller her feet must be, and it is customary to find women in China who can wear shoes three and four inches long. These shoes are usually made of silk and richly ornamented; durability is of little consequence, for the poor woman has sacrificed her ability to walk, and must remain a cripple all her life.

Among the peasantry of Europe the wooden shoe, or French "sabot," has been in common use for centuries. It is durable, cheap, and said by the wearer to be comfortable. We occasionally find these shoes on the market in the United States in towns where the surrounding country is largely settled by immigrants. The older people in these communities still cling to the customs of their native land and prefer the wooden shoe to that of a more modern and comfortable make.

The early settlers of America did not desire stylish shoes. But they were in great need of a covering for the foot which would serve as a protection against the cold and the rough ground which they worked. Some attempted to use the moccasins of the Indians, but they were not durable for such work as clearing the land and breaking it up for tillage. The shoemaker was an early necessity in the colonies, and we

find him among the earliest craftsmen who came to the New World.

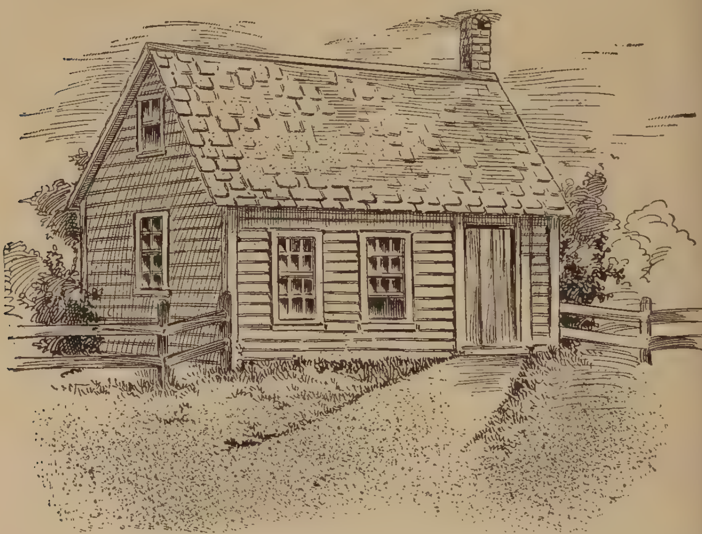
Among the records of Plymouth colony there is an old document bearing the date of 1629, stating that Thomas Beard with "hides" both upper and bottom was shipped out on the May-flower, and the governor was recommended to give him "lodging and diet." Beard must have been heartily welcomed by the colonists, for we learn that

MAKING SHOES BY HAND

he was presented with fifty acres of land in addition to his living, as recommended to the governor of the colony. The shoe-making industry of the United States had its origin in Lynn, Mass., which city has since become the largest shoe-manufacturing center in the country, if

not in the world, and is known as "The City of Shoes."

In the beginning, the shoemaker traveled from house to house with his kit of tools, working up the leather of the family. The tools were poor,



AN OLD LYNN SHOE SHOP

the leather was usually of an inferior quality, the workman was unskilled, and the product anything but what the well-dressed lady or gentleman of to-day would care to appear abroad in. Yet it gave necessary protection and a good degree of comfort to the wearer. The industry in and around Lynn soon grew to such propor-

tions as to call for the erection of shops, and the shoemaker stopped traveling. But this custom was continued for many years among the more sparsely settled portions of New England, and the writer distinctly remembers when it was in vogue among the Canadian farmers of the Province of Quebec, and almost under the shadow of Mount Royal.

The old-fashioned shoe shop was a small one-story building containing a room from 12 to 15 feet square, with windows at the ends and side, and a fireplace in one corner. The workmen had their benches placed around the sides of the room and here with their tools, which comprised a hammer, lap-stone, knives, and hones, master-workman, journeyman, and apprentice met on the same level, and shared alike.

The occupation was one which induced to steady habits, and gave plenty of opportunity for meditation. We find that the old-time shoemaker was, with scarcely an exception, a man of good habits, strong character, and an excellent citizen. It was of men like these that Whittier wrote:—

> The foremost still, by day or night,
> On moated mound or heather,
> Where'er the need of trampled right
> Brought toiling men together;
> Where the free burghers from the wall
> Defied the mail-clad master,

Than yours, at Freedom's trumpet-call,
  No craftsman rallied faster.

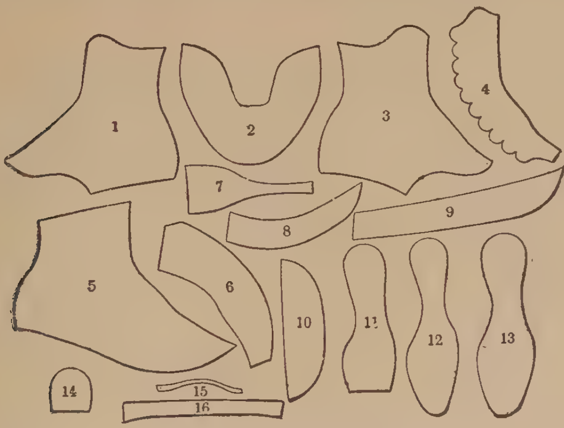
Let foplings sneer, let fools deride,—
  Ye heed no idle scorner;
Free hands and hearts are still your pride,
  And duty done, your honor.
Ye dare to trust for honest fame,
  The jury time empanels,
And leave to truth each noble name
  Which glorifies your annals.

* * * * * * * * *

The red brick to mason's hand,
  The brown earth to the tillers,
The shoe in yours shall wealth command,
  Like fairy Cinderella's!
As they who shunned the household maid
  Beheld the crown upon her,
So all shall see your toil repaid
  With hearth and home and honor.

The essential parts of a shoe are the upper, the sole, and the heel stiffening. These may be further subdivided into the vamp for covering the front of the foot, the large and small quarters for encircling the ankle, and the button piece for the uppers; and the outer and inner sole and heel for the bottoms. The shoemaker must sew these pieces together in the desired form, fasten them to the sole which has been previously cut, attach the heel and give the whole the finish and style necessary to fit it for the market.

Whatever machines are used in making a shoe must do these various lines of work. Modern inventions have necessitated the subdivision of these operations to the minutest detail, and per-



PARTS OF A BUTTON SHOE

1, large quarter; 2, vamp; 3, small quarter; 4, button piece; 5, drill lining; 6, glove button-piece lining; 7, heel lining stay; 8, button stay; 9, top stay; 10, heel stiffener; 11, sole lining; 12, inner sole; 13, outer sole; 14, heel lifts (six); 15, steel shank, 16, rand.

fected machines for performing them all successfully, even much better than could be done by hand labor.

The modern shoe factory with its complex machinery and large number of operatives has been an institution of slow growth, and has developed as the demands upon the trade have called for larger facilities. From the unshapely

shoe of the traveling cobbler, came the well-made shoe of the old hand-shop—indeed, the shoemakers of Lynn and vicinity became so skillful before the Revolution that a Boston paper bearing the date of 1764 speaks of the women's shoes made in that town as being superior to those imported from the mother country.

The Revolution gave a great impetus to the industry, as the demand for boots for the Continental army was far beyond the ability of the shops to supply. After the war, however, heavy importations of shoes from England caused a decline, but the country recovered from this in the course of a few years, and the shoemakers became more prosperous than ever. Still all the work was done by hand, and without any division of labor. A pair of shoes a day per man was considered a good output, and in this way the work went on for many years. Finally, some enterprising manufacturers conceived the idea of grouping their workmen, consequently several shops were combined. Some of the workmen were given the cutting, others the sewing of the uppers, and others the fastening on of the sole. The advantages of this plan were at once so apparent that it soon became general. Much of the lighter work was let out to women to be done in the home, and "Hannah Binding Shoes" could be found in almost every household in Eastern Massachusetts.

This was really the beginning of the factory system. The rolling machine seems to be the first machine introduced, and this was in 1850. By means of this a workman could accomplish in a minute what would take him a half hour to do with his hammer and lap-stone: viz., to press the sole leather together so as to make it compact, and at the same time pliable for working. The splitting machine soon followed. By the use of this the leather was made of uniform thickness. Before the introduction of this machine all paring down had to be done by hand. This required a good deal of time, and did not secure as good results as could be obtained with machinery. These machines were operated by hand or foot power.

It was, however, left for the sewing machine to revolutionize the shoe industry. Within a few years from its first appearance, we find various modifications of it in the shoe factory, each made for its special kind of work. The next great invention was the McKay sewing machine for sewing the sole to the uppers. In the hands of a skillful operator this machine will sew the soles on to 800 pairs of woman's shoes in ten hours. Other machines for fastening the soles with wire, and also with nails, have been invented, and are now in constant use in all large factories. At first shoes made by these machines did not have as good a finish as those made by

hand; but the invention of the Goodyear welt machine, which grooves the sole for sewing, now enables the machine to rival the most skilled workman. Two other machines which have added much to the efficiency of the factory are the Bigelow heeling and attaching machines. The first presses the leather heel into a solid mass, and sets the nails ready for driving; the second with a single motion fixes the heel in place. Machines for cutting the soles, shaping and finishing the heel, blacking, and polishing are also found in great variety. Each does its special work. In fact, in the modern shoe factory, the work of the operators may be said to consist in passing the pieces from one machine to another until they come from the last a finished shoe. In no other industry is the division of labor more perfect, or is there a larger proportion performed by machinery.

THE MANUFACTURE

Let us now follow the leather through the factory, and see how it becomes a shoe in passing through the hands of a large number of operatives and being treated by these numerous machines. The factory is divided into three departments: that in which the work is done on the soles, that in which it is done on the uppers, and that in which the shoe is put together.

IN THE CUTTING ROOM

The first process is that of cutting, and we will begin with this in the department of the uppers. This is all hand labor. We find workmen standing before high tables, each with a pile of stock beside him. Each cutter has a full set of patterns, and a small knife with a narrow blade so bent at the point as to somewhat resemble a hook. This knife he keeps very sharp. The cutter must plan his work so as to get the largest number of pieces out of each skin, and also to cut the vamp from that portion which is the most durable, and to cut it with his pattern in such a position as to have the length run the right way of the leather, or it will not finish well. One might think that these problems would lead to hesitation over each new skin, but the practiced eye of the cutter enables him to see at a glance what he can do to the best advantage, and he rapidly lays pattern after pattern, and runs his knife around it until no pieces remain large enough to work up. So carefully is the work planned that scarcely any waste remains after the cutting. The linings are also cut in this room,—some from a light leather, and some from cloth. As the pieces come from the cutting tables, they are so grouped with the linings that each package represents the uppers for a case of shoes. These are ticketed, fastened together, and sent to the sewing room.

In the sewing room we find several long tables

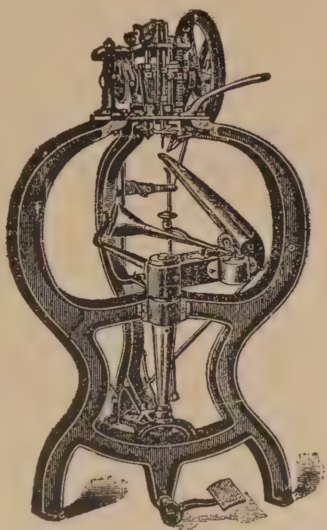
upon which are arranged sewing machines as near together as the operatives can sit and work to advantage. As a general thing, each line of machines is completed in itself, that is, it contains all the machines necessary to prepare the uppers for the sole. Each machine does but one thing, and the operative soon acquires a degree of skill which enables her to do that with a great degree of rapidity. One sews the vamp to the quarters, another sews the quarters together, another makes only buttonholes, another sews the binding, and so on, until the pieces have passed down the table and come out a finished upper ready for the sole.

The cutting of the bottoms is entirely different from that of the uppers. The stock is heavy and hard to work, consequently needs heavier machinery and stronger tools. The insoles are usually cut by hand—the workman using a die having the shape of the sole, and driving it through the leather with a heavy mallet. The outer soles are mostly cut by machines. The sides of leather are first cut into strips, the width of the strip being the length of the sole. These strips are rolled and run through the splitting machine, and then placed in a machine having a knife moved by a revolving table. The path of the knife is the outline of the sole, and it cuts the bottoms very rapidly. The heels are usually cut by hand by the use of dies, as in this way

nearly all of the small pieces can be used, and in order to prevent waste some dies cut only half lifts. These pieces are tacked together by boys who build the heels, and make them ready for the heeling machine. After cutting, the sole is soaked to make it pliable and then put into the press which shapes it for the shoe, giving it the bend at the instep and toe.

We now pass to the third department, where the sole and uppers meet, and the shoe is completed. Here we see the greatest skill displayed and find the most complicated machinery. The last, which is really a wooden foot to which the shoe was cut, is first placed in the upper to prevent crushing or deforming; on the bottom of the last the inner sole is laid. A workman places the whole in a clamp made for the purpose, and with his pincers proceeds to draw the upper down and nail it to the inner sole. This work is done by hand and requires considerable care, so as not to wrinkle the upper or draw it out of shape in the operation. Another workman fastens the outer sole with a couple of small nails to hold it in position. This is done by a machine. If the shoe is to be sewed, it now goes to the welt machine which cuts a groove for the stitches, and from there to the McKay sewing machine which sews the sole in place. This machine is a very interesting contrivance. It has two points resembling needles, and opera-

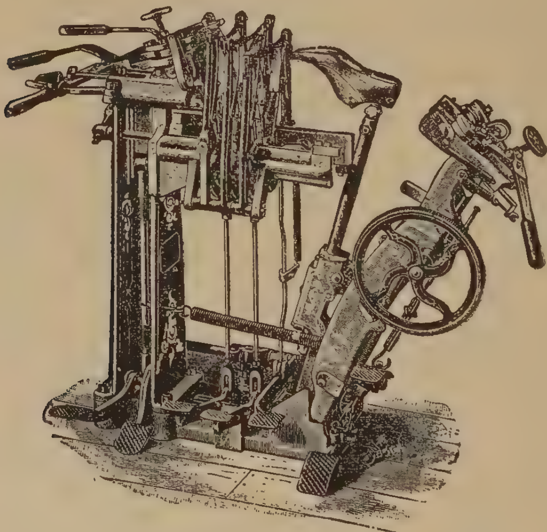
ting one on the inside of the shoe and the other on the out. They come together very much like the thumb and forefinger. One carries the thread, which passes through a pot of melted wax on its way, while the other has a hook very closely resembling that on an ordinary crochet needle. With this hook the loop is made which completes the stitch. After sewing, the welt is cemented and pressed back into place so perfectly that it does not show at all.



MCKAY SEWING MACHINE

Nailing and wire-sewing machines fasten the soles on to cheaper grades of shoes, and are equally ingenious. The nailing machine makes its nails from a little ribbon as it uses them, and will nail a sole to a shoe as quickly as it can be sewed. The wire cable machine uses a brass wire on which a thread is cut. This machine inserts the wire, turns it half way around, so as to get the effect of the thread, and cuts it off at the right length. Since the invention of this machine, pegged

shoes have almost wholly disappeared from the market, as the cable-sewed shoe has taken their place. The heel is now attached by the machine already described, and the shoe is ready for finishing.



COPELAND RAPID LASTER

The heel is turned and fashioned on a lathe, the edges of the sole are next trimmed and finished, and the shoe passes on to the blacking and polishing machines. These usually occupy a room by themselves known as the finishing room. Here all the delicate touches which have for their purpose giving the shoe a stylish

appearance, are put on. This room exists for the benefit of the market, as the operations do not add in the least to the benefit of the shoe. Here the soles are sand-papered, and polished so as to give them that peculiar white appearance so often seen. Most dealers have their firm name stamped upon the shoes, and this is also done in this room.

After leaving the finishing room laces need to be inserted, or buttons sewed on, as the case may be. The shoes are then packed for shipment. If of high grade they are usually wrapped in tissue paper, and each pair is placed in a separate box. Cheap shoes are packed in the large cases without separate boxing.

The marvelous rapidity with which the work is now done is in marked contrast to that of the old-fashioned shop, where a pair of shoes was considered a good day's work for one man. A few years ago a distinguished gentleman from England visited one of the factories in Lynn, and expressed his desire to learn the time necessary to make a pair of shoes. The manager selected a woman's shoe of good standard grade as a fair test, and hurried his guest from point to point in his attempt to follow the process as the pieces left the cutter's table, until at the end of twenty minutes the finished pair of shoes was placed in his hands. While this may be considered a fair test of rapidity, yet the unusual method used in

order to pass the shoes through the factory undoubtedly took somewhat longer than would be required in the regular work; in other words, the factory working in its regular way could produce shoes faster than at the rate of a pair in twenty minutes.

For a long time Massachusetts was the center of the shoe industry in the United States, and many of her large towns owe their development and prosperity to the shoe factories. Within the last few years, however, large factories have sprung up in New York, Philadelphia, Chicago, and other large cities, and smaller factories are now scattered very generally over the country. This industry consumes more leather than all others combined. We are now making more boots and shoes than we can use, and they are beginning to find a ready market in other countries. During the past five years our export trade in boots and shoes and leather has amounted to several million dollars annually, and it is constantly growing. The total value of the boots and shoes manufactured in the United States yearly amounts to a stupendous sum and the industry is constantly expanding.

DRESSED MEAT

WERE we to group all great industries of the world by their products, we should find that in extent and volume those which have for their purpose the furnishing of food for the people would far exceed any of the others. The largest branch of the food industries in the United States is that generally known as meat packing.

It is not so very many years since the old-style country butcher was the general source for the supply of meat in cities and towns. In remote localities, his white canvas-topped wagon is still seen during the summer months, bringing to each door its meager assortment of meat. The country butcher purchased his animals of neighboring farmers, slaughtered them himself, and retailed the meat to his customers. The building in which the animals were dressed was

known as the slaughter house, and, on account of the disagreeable odors arising from it, was compelled to be located at a good distance from any dwelling. Here the meat merchant was his own butcher, chandler, and soap-maker. The meat which he served up to his customers was not always the tenderest, but as he had no means of improving its quality, they were under the necessity of making the best of the situation. This they did by making the pot or oven do the work of the refrigerator.

As railways multiplied and continued to extend their lines further and further into the country, the custom of shipping live stock to the markets in the great cities became common. At first the slaughter houses of these cities differed from those in the country only in size. Animals were slaughtered and dressed after much the same manner in both, and there was little or no division of labor.

As the meat business increased in proportion, it became necessary to change the methods both in shipping and preparing for market, and the modern packing house is the outgrowth of this demand. The present system originated in Chicago, where it has continued to grow, until at the present time, that city has the name of possessing the largest meat-packing business in the world.

The first yards in Chicago for herding beef

cattle were built in 1850, and were known as stock yards. During the next fifteen years a number of these yards were built by different railway companies. These were at some distance from each other, and the inconvenience and delay caused in transporting stock back and forth led to the formation of the company which arranged the present system known as the Union Stock Yards. Other similar establishments are found at Kansas City, Omaha, St. Paul, and some other cities; but the business done at the Chicago yards exceeds that of all the others combined. A look at these yards will give us an idea of the meat-packing business for the country

The Union Stock Yards of Chicago are located in the southwestern part of the city, and cover, including buildings, one square mile. The importance of this small area in the commercial world may be partially realized when we learn that the volume of business transacted here exceeds in value by several millions of dollars that of the total grain, lumber, and dry goods business of the entire city each year. That this vast amount of business may be transacted with the greatest dispatch and accuracy, special arrangements are required.

The yards are divided into sections separated from each other by streets and alleys like the blocks in a city. Each division is subdivided into a number of smaller yards and pens, by high

A VIEW IN THE UNION STOCK YARDS, CHICAGO

board fences. Gates are found across the streets and alleys and at all crossings, so that the animals may be readily driven in any direction desired. There are at present four hundred and seventy-five acres of these pens, and three-fourths of them have brick paving, as do all the important streets. Special arrangements, called chutes, for the loading and unloading of stock from the cars are found in connection with the railway tracks. Railways extend through the yards to such an extent as to bring most of the pens in close proximity to the cars. Still it is impossible to reach all sections in this way, so driveways, usually known as viaducts, lead from one end of the yards to another. These are elevated to a sufficient height to be out of the way of all work in the yards or about the streets. Another set of viaducts leads up to the top of each of the great packing houses, which are situated in the midst of the yards. The pens number 13,000, and are divided into three classes: one for cattle, one for sheep, and one for hogs. The cattle pens are open, but those for sheep and hogs (numbering 8,500) are covered. The covered pens occupy seventy-five acres, and many of them are double-decked, or what we would ordinarily term, two-storied; this doubles the capacity.

The yards contain twenty-five miles of streets, thirty-eight miles of water troughs, ninety miles

of water pipes, fifty miles of sewerage, and six hundred and twenty-five chutes for loading and unloading the stock to different sections of the yards so as to prevent overcrowding in any locality.

The necessity for such perfect arrangements can be seen when we realize the large number of animals received each day. For the last ten years an average yearly total of over 16,000,000 animals was sold for the stupendous annual average sum of over $350,000,000. That means that a general average of considerably more than $1,000,000 worth of living property was sold and delivered every business day during the last ten years on the Chicago live stock market. Since the Union Stockyards of Chicago were established there has been received and sold on this market a grand total of more than 550,000,000 animals.

The animals included in these shipments are cattle, calves, hogs, sheep, and horses. Lest some one should obtain a wrong impression from this statement, we must remember that in connection with these stock yards is one of the largest horse markets in the world. The horses included in the shipments are for sale, not for slaughter. The number of hogs received is far greater than that of any of the other animals. Sheep come next, then cattle.

Our geography teaches us that certain sections of the United States do not have enough rainfall

during the year to enable the farmer to raise crops successfully. Many of these sections, however, produce an abundant growth of grass well suited to cattle. Those localities which have mild winters, are favorable for the raising of cattle, and here we find the great stock ranches. Most of these are located in the far western States that border on the eastern slope of the Rocky Mountains. In the extreme northern part of this belt, the winters are too severe to admit of the successful raising of stock, as the expense of housing and feeding is so great as to prevent any possible profit for the business from the ranches in this section of the country.

Most of the cattle and sheep which come to the stock yards in Chicago and the other cities named, are shipped from the States in this paying belt. The manner of shipping is interesting, as it shows as great an advance over old methods in the care and comfort of animals as does the modern train for passengers over that of twenty-five years ago.

The old-fashioned stock car was a rude structure consisting of a platform car inclosed with what was practically a high board fence, and open at the top. Into this the cattle were crowded as closely as they could stand, and during transportation were exposed to storm and the pangs of hunger and thirst if the journey happened to be a long one. The modern stock car has a far

different arrangement. It is covered and inclosed at the top so as to protect the animals from storm. Along each side run troughs for water, and the trucks are fitted with air brakes; besides, the cars are fitted with such buffers and coupling devices as to prevent all the jolting possible from starting and stopping. Cars intended for transporting sheep and hogs are usually double-decked, which gives them double capacity.

Stock is now shipped in special trains containing nothing but stock cars. These trains have the right of way over all other freight, and sometimes over local passenger trains. They travel at a high rate of speed and cover the distance between the shipping point and the stock yards in the shortest possible time; but if this time exceeds twenty-four hours, the regulations on all roads now require the stock to be unloaded, fed, and watered, and allowed to rest. This care in shipping is not only merciful to the animals, but also of benefit to the shipper, as it enables the cattle to reach the market in a much better condition.

As the trains arrive with the loads of live stock, the cars are automatically weighed before being switched into the various receiving pens or yards, where they are unloaded at the rate of about two minutes to a car. The animals are placed in receiving pens, from which they are soon moved to feeding pens, where they are fed

and watered, and allowed twenty-four hours' rest. During summer, the cattle are usually given a shower bath after being unloaded. The greatest kindness is shown in treating the animals. No driver is allowed to beat them, and no animal not in sound health is received at all.

Soon after the stock is unloaded, the buyers are on hand. Their work is highly specialized; one man is a buyer of cattle, another of sheep, and another of hogs. Each buyer must be an excellent judge of the quality of the animals and the relative amount of waste in dressing, for error in judging these particulars would involve his employer in heavy loss. Transactions involving thousands of dollars are completed with surprising rapidity. The animals are then inspected, weighed, and sent to other pens, from which they go either to slaughter houses, or are shipped to other points.

The buyers are accompanied in their rounds by inspectors who represent the Board of Health of the city of Chicago, the State Board of Live Stock Commissioners of Illinois, and the Department of Animal Industry of the United States government. All animals are subjected to the most careful inspection, and no diseased, maimed, or bruised animals are allowed to pass to the slaughter pens. The State and city humane societies for the prevention of cruelty to animals also work with the inspectors. The

animals unfit for meat are killed and worked up into such products as soap, glue, etc., so that the owner gets all for them possible. Specially constructed carts are provided for hauling disabled animals to places of slaughter. These arrangements prevent total loss, and are just to the shippers as well as the public.

On a morning after the arrival of a large number of cars, the stock yards present a lively scene. Buyers and drivers on horseback are hurrying from one part of the yards to another. A large number of men are employed in feeding stock, driving cattle and sheep from one set of pens to another, and unloading cars. Inspectors are on the look-out whenever buyers are at hand. All seems to be hurry and bustle, yet a few minutes of watching reveals the most careful arrangement and systematic work. In order that the financial part of the work may be conveniently managed, two large banking houses are established within easy reach of the pens. A daily paper is also printed here, which is entirely devoted to the interests of the business.

THE PACKING HOUSES

Situated in the midst of the yards, and covering, in all, some hundreds of acres, are the packing houses of Armour & Company, Swift and Company, Wilson and Company and several smaller firms. Each of these is almost

a city in itself, and the volume of business transacted each day far exceeds that of many small cities. Each establishment is divided into departments, each of which has its separate buildings. The most important of these are the cattle, hog, and sheep houses. There is no better way to become acquainted with the business of turning cattle into beef, hogs into pork, and sheep into mutton, than by going systematically through these houses. Let us begin with the steer and see what befalls him from the time he becomes the property of the packer, until he is served up on our tables as steak and roast.

The cattle are driven up the inclined viaducts to the slaughter pens, from whence they work down to the first floor of the building as they pass from one process to another. At the end of the viaduct, a number of small pens are found, each just large enough for a single steer. As the unsuspecting animal enters the pen, a drop door falls behind him and shuts him in. A blow between the eyes from a heavy sledge in the hands of an expert knocker, kills him instantly. As he falls, a shackle is fastened to one hind-leg, and he is immediately strung upon a trolley rail and started on his journey through the packing house. The first workman he meets makes a stab in the throat for the purpose of bleeding. The next begins the process of skinning, and so on. As the animal passes along down one rail

and up another, workmen stand in rows along these lines, and each man has his particular part in the process, and does nothing else. One opens the skin down the front, which prepares it for removal; another skins the tail, and so on. Others, by well-aimed strokes of the cleaver, divide the carcass into sides. Pausing among these workmen, we find others with brushes and pails of hot water. It is the duty of these to remove any blood stain or other evidence of uncleanness, so that the sides, when dressed, are perfectly clean and white.

As the sides pass from the slaughter room, they are weighed, usually four at a time. This is accomplished by a special scale which marks the weight as the trolley passes along. The most careful system of checking and weighing is maintained, that strict account may be kept of each animal killed. The weight of the sides of a steer in good condition to kill, should be about fifty-seven per cent of the animal's weight when alive.

After weighing, the sides are sent to the cold storage rooms, or "coolers," as the workmen call them. Here they remain for three days, when they are either sent to the wholesale markets or shipped to other cities. One of these rooms is an impressive sight. The white sides hang in rows with narrow aisles between them, affording just room enough for one to walk in (if he is

SIDES OF BEEF IN THE "COOLER"

careful). These aisles are called streets; but in this case, the streets are only man-wide. Here one can, if he so desires, wander at will up one street and down another, between thousands and thousands of sides of beef. If he should remain any length of time in one of these cooling rooms, he would need his overcoat, for the temperature is kept very near the freezing point, and is carefully guarded. Thermometers are stationed at convenient intervals, and once an hour these are read and recorded by the temperature man, who gives his entire time to this work. The temperature of the cooler is maintained by the use of ice, brine pipes, and ammonia. Some firms prefer the ice, while others rely almost wholly upon the ammonia process.

The cutting of the sides is determined by their destination. Those for the home market are cut into rump, side, and shoulder; those shipped in refrigerator cars are cut into quarters. The line of division depends upon the city to which the beef is sent. Boston wants three ribs on the hind-quarter; New York, one; while Brooklyn demands hind-quarters without any ribs. The beef is shipped in refrigerator cars, which are so common now that their appearance is familiar to everyone. The quarters are suspended from a hook in the top of the car. Each car holds from 100 to 140 quarters. By the use of ice these cars are kept at about the same temperature as the

cooler from which the beef is taken. That which is exported to Europe is carried in refrigerator ships, so that from the time it is placed in the cooler at the packing house, until it reaches the customer, the beef is kept at a temperature just above freezing point. This allows it to become tender and sweet. All beef should be kept in this way for at least eight or ten days, and some of the choicest cuts are kept from three to four weeks.

As yet we have taken no account of the rapidity with which this work is done, or the number of workmen through whose hands the steer passes before the sides reach the cooler. In the slaughter pens of one of these large establishments, eight or ten cattle drop every minute. Placing the lowest estimate of eight a minute upon the work, this gives 480 an hour, or 4,000 a day. This means at least 6,000,000 pounds of meat given to the world every twenty-four hours, by a single firm. Within forty minutes from the time the hammer falls upon the head of the luckless steer, his sides, white and clean, are hanging in the cooler; and in reaching this destination, they have passed through the hands of 150 workmen.

In the large slaughter houses of Chicago, there is one marked exception to the usual method of killing. The city contains a large number of Jews, and these people require their beef to be

killed directly by bleeding, in accordance with the old Jewish law. Each day a sufficient number of animals is slaughtered in this way to supply their markets. They maintain, at their own expense, special inspectors, at the slaughter houses, and all beef prepared for Jewish markets bears their stamp.

All meats are subjected to government inspection after killing, as well as before, and you will notice that the quarters and sides of beef which you find in your meat market, have the inspector's tag fastened to them. If the meat is exported to foreign countries, it is subjected to microscopic examination to meet the requirements of these governments. With all this care, it is practically impossible for unwholesome meat to be placed on the market. On this account, if no other, beef from the large packing houses is to be preferred to that of the local butcher.

Besides the fresh beef, which constitutes by far the largest part of the output from the cattle houses, there are several other important products. One of these is dried beef, which is made from the choicest cuts by pickling, smoking, and drying. Another is pickled tongues, which are considered quite a luxury, and on this account bring a high price. Canned beef, both fresh and salt or corned, is now also an important output, and its preparation constitutes quite an industry

in itself. Then there is the famous beef extract, used in soups and beef tea. Each pound of this extract contains the nutritive value of fifty pounds of the best beef, all packed into this small compass by evaporation and chemical processes. This extract is high valued, and finds a ready market in all the leading countries of the world.

While the preparation of beef is a work of great interest to the average observer, the preparation of pork is still more interesting. The building in which the numerous operations connected with this branch of the business are carried on, is known by the euphonious name of "hog house." It is a place of startling sights and sounds,—and in some parts, of odors, too, for that matter.

The hogs, like the cattle, are driven up inclined viaducts to the top of the building where they are herded in small pens. From these they are run, a few at a time, into the pen where they are shackled. A chain is deftly slipped around a hind-leg of the unwary porker. The chain is attached to a large revolving drum which hoists him to a trolley rail above, and automatically starts him on his journey. As the pig moves down the rail, he meets his executioner, who, with one stab of the knife, ends his life. The stuck pigs move on to the scalding vat, into which they are dropped. After remaining in the

vat long enough to have the bristles loosened, they are lifted out on to a platform at the foot of the scraping tower, which is a machine demanding a moment's notice. The scraping tower contains two shafts, in each of which is a vertical cylinder set with arms from a foot to a foot and a half in length. Each arm contains an attachment which resembles a small shovel, in appearance. This is attached with a spring, and constitutes the scraper which removes the bristles. A hook is inserted under the pig's lower jaw; this is attached to a chain which draws him up one shaft of the tower and lets him down the other. He pursues a spiral pathway both in ascending and descending, and is dropped upon a slowly moving platform, minus most of his bristles. A row of workmen stands along each side of this platform, and as the pig passes along, each performs some part in finishing the dressing. From this platform, the carcass is again run upon a trolley, and goes on its way through the finishing room. By the time it has left the last workman in the long line it has been completely cleaned, dressed, and divided in halves which are held together by leaving small portions uncut at the hips and shoulders. The pork is then weighed and passed to the first cooling room; here it remains until the animal heat is removed, when it is transferred to the cooler proper where it remains for two or three days. The arrange-

ment of these coolers is somewhat similar to that of the beef cooler, but they are necessarily much more extensive. The pork cooler of Armour & Company alone has a capacity of 30,000 hogs and usually contains 23,000. The temperature ranges from 28 to 34 degrees.

After cooling, the sides are sent to the cutting block where they are quickly separated into hams, shoulders, sides, and loins. The rapidity with which this work is done is astonishing. As the side shoots down the shaft to the block, a workman with a large knife, made for this purpose, and called a cleaver, severs it with two blows into ham, side, and shoulder. It matters not how large the side, each stroke sends the cleaver through to the block; the ham shoots off in one direction, the shoulder in another, and the side in a third, each for further division or trimming.

A trimmer, skillful to a marked degree with his knife, with a single turn of the hand gives the ham its rounded shape and throws the trimmings into an elevator to be taken to the sausage department. As the sides pass to another block, one cutter saws the ribs from the backbone, another at one pull with a draw knife cuts out the loin, while a third takes out the ribs for spare rib roasts. The loins are wrapped in paper for immediate shipment. The hams are sent to the pickling vats, and the sides are usually dry salted

for salt pork and bacon. Most of the shoulders are pickled and smoked after the bone is removed, and appear on the market as "California hams."

The preparation of smoked meat is an important branch of the business, and has several build-

THE PORK "COOLER"

ings devoted to it. Much space must necessarily be given to the pickling vats, for several weeks era required for the process, and from 16,000 to 20,000 hams are received each day. Then the

smoking ovens, for like reasons, take up a good deal of room. These ovens are an interesting sight. The hams are suspended on hooks so arranged that one layer might be said to just overhang another, and these extend story above story, from the bottom to the top of the building. One of these smoke-houses contains thirty-seven ovens, and has a capacity for 1,295,000 pounds of meat. When taken from the pickle, the hams are thoroughly washed with hot water before placing them in the oven. The smoking is done with hickory wood and a powdering of mahogany dust, and occupies from 12 to 14 hours, while the pickling occupies several weeks. In these houses, nearly 20,000,000 hams are prepared for the market each year. Each foreign country has its own peculiar likes and dislikes, and the packing houses adapt their methods to each country, as may be demanded.

Another department of the pork industry, is that in which sausage is made. We see sausage a few links at a time. Here it is found by the ton. In this department are worked up all the pieces which come from trimming hams, shoulders, sides, etc., besides other parts of the pig which can not well be used in any other way. After being trimmed of the skin and so assorted as to give the proper proportions of fat and lean meat, these pieces are fed to the cutting machine where they are chopped to the degree of fine-

ness found in the excellent sausage made by these houses. After seasoning and cooling, the sausage is filled into the links. One of these firms produces over 25,000,000 pounds of link sausage a year; enough, if strung together, to reach from New York to San Francisco and then extend some hundreds of miles along the Pacific coast. And besides these there are other varieties; some dried, some smoked, and some sold in bulk, so one can at once see that the sausage factory occupies an important place in the business of pork packing.

The lard rendering is another branch of the business of no mean significance, as we see from the fact that a single lard plant has a capacity of 300,000 pounds a day; and this quantity is produced by the fat trimmings alone, of one hog house. The animal fat is melted and purified in great kettles, then partially cooled by passing over cylinders filled with ice water. It then passes through pipes into the filling room, where it is run into pans, jars, and boxes of various sizes, for shipment.

Inside the hog is a small quantity of the purest animal fat. This is known as leaf lard, and is set aside for the manufacture of butterine. A portion of it, after being purified until in a liquid state it is as transparent as water, is mixed with a proportion of oleo, prepared in a similar way from beef suet. Another portion of the leaf is

made into neutral lard and fed into a chopping machine, which cuts it into very fine particles. This chopped lard, purified lard, and oleo in proper proportions, are now mixed with ordinary milk, butter and cream, and the entire mass is churned for about ten minutes. This is all the secret there is about the production of butterine. It is simply a compound of butter and cream, with the two purest fats that can be obtained. After churning, it is worked, salted, and packed like butter. Farmers claim that the manufacture of butterine injures the sale of dairy products, and ought not to be allowed. On the other hand, we must remember that it has become a common article of food in thousands of homes where butter was a rare luxury, and in this way is a great blessing to a large class of people.

From the great variety of products obtained in working up the hog, and the importance of each, we come to realize that this frequently much-despised animal is, after all, very useful, valuable alike as a source of income to the farmer, and a means of supplying food to the people. This value is fully realized, as seen from the great number of hogs slaughtered each year. In the great packing houses of Armour or Swift, these amount to 12 a minute, 720 an hour; practically 8,000 a day, on the average. The work is done so rapidly that in twelve minutes from the time

the pig is shackled, his sides are hanging in the cooling room.

In the sheep house the work is carried on with the same dispatch and on an equally extensive scale, though in value the output of this department of the business is considerably less than that of the others. There is also a large poultry department connected with each of these establishments. In fact, they are amply equipped for supplying the world with all the different kinds of meat eaten by civilized man.

The by-products of the packing houses deserve a moment's notice. The description of their manufacture could easily fill a small volume. The most important of these by-products are soap, glue, and fertilizer; with the understanding that the hides pass to the tanner and are not considered in this list. The soap-factory works up those parts of the fat which are not suitable for other purposes, and "Armour's Soap" and Swift's famous "Wool Soap" are well known all over the country. Much of the soap material is also sold to the other manufacturers. The glue factory extracts the gelatin from the hoofs and legs of cattle. The finest quality is made into cooking gelatin, and the other into glue. The hairs from the cattle, bristles from the hogs, and wool from the sheep all find their place in the world's industries. The blood is boiled and made into a valuable fertilizer. The horns of

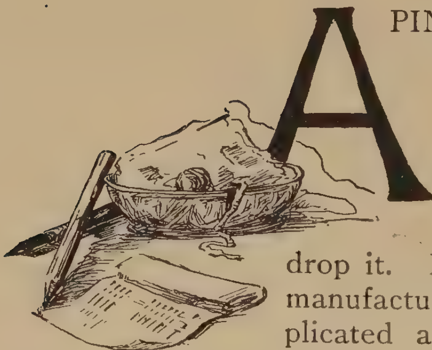
the cattle are made into buttons, knife handles, and other ornamental work. Nothing is wasted and nothing lost. Every part of the animal entering the slaughter pen is made, through the wise planning, scientific research, and ingenious invention of the men who have built up this extensive business, to contribute something to our comfort and happiness. The importance of the meat-packing industry in the United States is well stated by the compiler of the last live stock report for the Union Stock Yard and Transit Company of Chicago. He says:—

"It may not be credited, but it is a fact, nevertheless, that were the activities at the Chicago Union Stock Yards and adjoining packing district to abruptly cease, there would be a break in the food supply of the world that would be so seriously felt that many business enterprises would be crippled; indeed, hunger in many cases would for some time follow."

Measured by the value of the output, meat packing is the largest industry in the United States.

PINS AND NEEDLES, PENCILS AND PENS

PINS



A PIN is so common and so cheap that we scarcely think it worth while to waste time in picking one up when we drop it. Nevertheless, its manufacture requires complicated and delicate machinery, and, until within the last few years, every pin passed through the hands of at least fourteen workmen before its completion. At present all pins are machine made.

Common pins are made from brass wire which is coiled upon large spools. The wire is drawn from this coil through a hole in a steel plate, which has the same diameter as the pin. It is seized by a pair of pinchers and thrust through a hole in another plate, where the end is struck by a hammer, which forms the head. The pin is then cut off the required length and falls into a

groove where it hangs by the head. On the lower side of this groove, the opposite end of the pin comes in contact with a rapidly revolving cylinder, by which means it is pointed. All this is done so rapidly that an endless stream of pins falls from the machine during its operation. The pins next pass between two grinding wheels which give them a still sharper point. After this they are dipped in a tub of polishing oil, and polished. They are then usually boiled in a solution of tin to make them white. After coating the pins are ready to be stuck in the papers. The machine which does this work is probably the most ingenious invention connected with the manufacture of this little article. The pins fall into a hopper arranged on an inclined plane, and having a number of slits. The pins slide along down these slits point downward. They are then caught and inserted in the paper, ready for market. One of these machines will stick 100,000 pins an hour, and the mechanism is so delicate that the least imperfection in the pin will stop the feeding until the obstruction is removed.

Black pins are sometimes made from steel wire, and sometimes from brass wire and coated with japan, but those made in this way are of an inferior quality, and not generally used.

There are forty-five pin factories in the United States, giving employment to 1,600 persons, and

turning out $10,000,000 worth of pins every year. The number of pins manufactured is practically beyond comprehension. A careful estimate made in the city of London a few years ago, showed that Great Britain alone was making 280,000,000 a week; at the same time, 120,000,000 were made in France, and an equal number in Germany, besides 30,000,000 a day made in the United States, and the output of other large countries. It is also estimated that only one pin out of every hundred made is worn out or broken by use, the other ninety-nine being lost.

When pins first came into use, they were very expensive and used only by ladies of wealthy families. When a lady was married, it was customary to give her a sum of money with which to buy pins; this gave rise to the term, "pin money," which now has an altogether different meaning.

NEEDLES

Although the manufacture of the sewing needle is not properly an American industry, its introduction here is pardonable on account of the interest we all feel in this little piece of pointed steel wire. The use of the needle is very old, and it was probably one of the first tools employed by men. Savage and barbarous nations have been accustomed to using pieces of

bone, or even thorns, to aid them in sewing their clothing together; and bone needles with eye holes have been found in the tombs of the ancient Egyptians and among the ruins of old Roman cities.

Steel needles were formerly made entirely by hand, but now a great part of the work is done by machinery. The manufacturer buys his wire, (which must be of the best quality of steel), in bundles, each containing several coils. The wire is first cut out into two-needle lengths. The cut wires are called blanks. As these are taken from a round coil, they are slightly bent and must be sraightened. The first process in straightening is to place the blanks in bundles and heat to redness, and then allow them to cool slowly. The actual straightening is now done by rolling them back and forth on an iron plate, with a tool called the smoothing file. The blanks are then pointed in a grinding machine. Only one end is pointed at a time, so the process has to be repeated for the other end. When ground, the needles are drawn from the grinding machine by a rapidly revolving pulley. They are then fed automatically into a machine which marks the place for the eyes; then the eyes are punched and the needles are "spitted," or strung on two wires. The projections caused by the stamping are filed off and the double needles are then divided between the eyes. Each row, still

strung on the wire, is placed in a vise-like arrangement and the heads are filed into shape.

Needles are tempered by heating to a red heat and cooling suddenly in oil, then exposing to a slow heat until a blue oxide forms on them, when they are allowed to cool gradually. Each one is then examined by rolling with the fingers on a smooth steel slab, and any that do not roll evenly are cast aside. They are next washed and scoured in soap to remove any coating of oil that may adhere to them. The eyes are then smoothed and polished. While in the cheap grades of needles this work is done by machinery, in all the best grades the eyes are polished by hand. After polishing, the heads are ground, and the points finished on a stone by hand. The final process is polishing the shank, which is done by passing the needle between rollers arranged especially for the purpose. They are then sorted according to size, put up in papers holding twenty-five each, and a dozen of these papers are placed in a package. With all the machinery now in use, the ordinary sewing needle passes through the hands of seventy workmen in the process of its manufacture. The finest needles are made in England, where most of those in use in this country are obtained.

Besides the common sewing needle, we have a great variety of others for as many different purposes, like knitting needles, crochet needles,

etc.; but sewing-machine needles are the most numerous and important of all these different kinds. These needles have the eye near the point, and a groove on one side for the thread. Some needles used in machines for sewing the welts on to shoes are in the form of an arc of a circle.

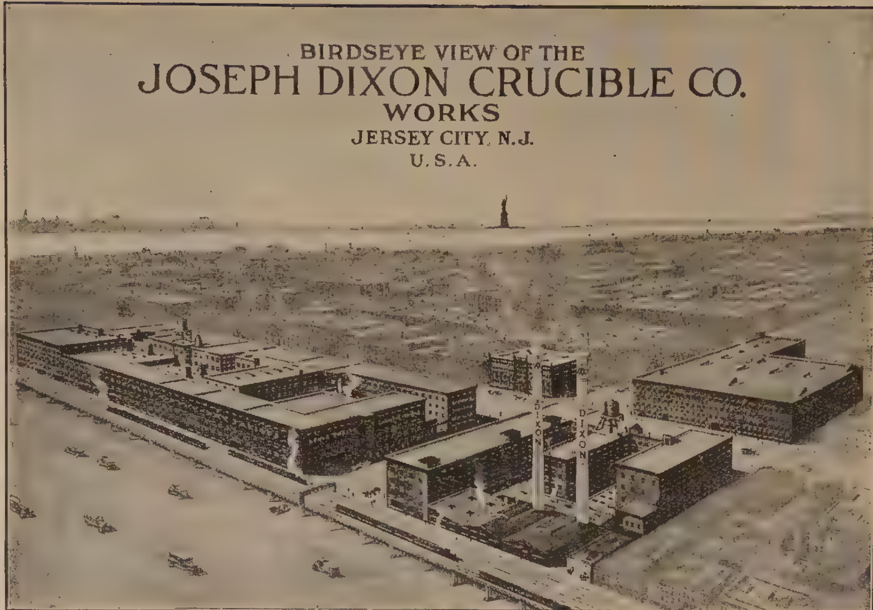
LEAD PENCILS

If we draw a piece of lead across a paper, it leaves a dull black mark. This quality of lead was known to the Romans and other ancient people many centuries ago. It was quite common to use small sticks of it for the purpose of marking. It is altogether probable that we get the name lead pencil from this custom. As you all know, a lead pencil does not contain any lead at all, but the substance which makes the mark, and is generally known as black lead, is a peculiar form of carbon, called graphite. Graphite, like lead, has been used for several centuries to mark with. It is so soft and brittle that it needs to be protected in some kind of a case in order to make it durable, and this led to the invention of the present form of pencils. Graphite is found in veins in rock, like coal, from which it is mined. The most important graphite mines in the United States are at Ticonderoga, N. Y.; others of note are found in England, in Siberia. and in the island of Ceylon.

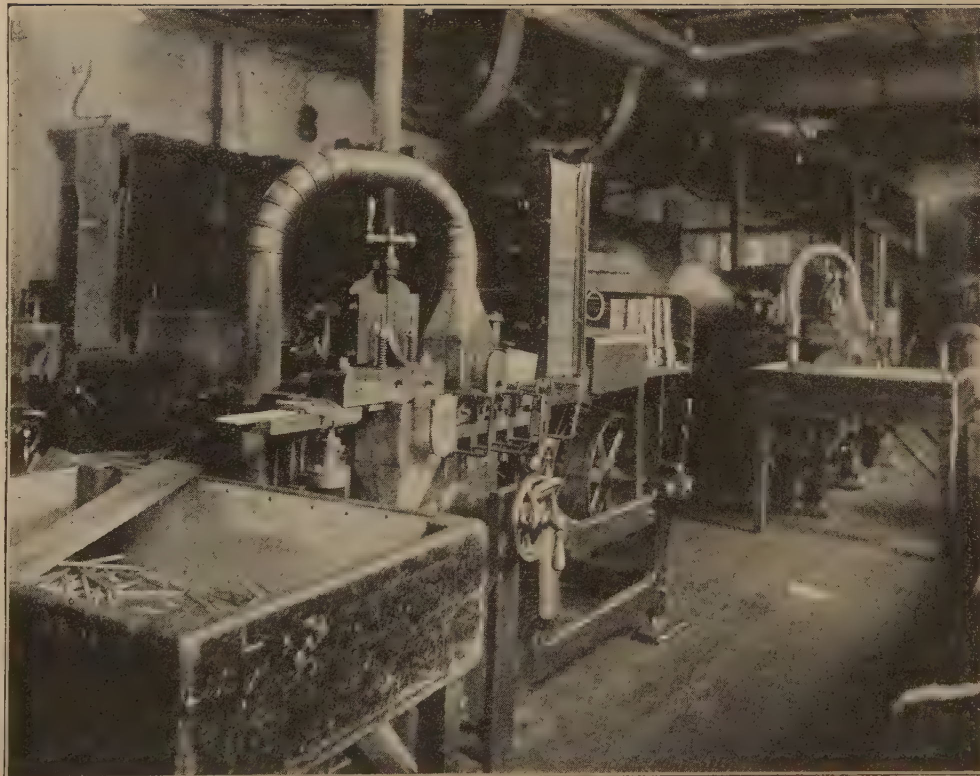
The first lead pencils were made by sawing graphite of the best quality into little bars and placing these in a case of wood. The German manufacturer, Faber, still continues to use this method. His pencils are known for their fine quality, and can easily be recognized by their square lead.

The American manufacture of lead pencils differs from similar works in Europe, in the method of preparing graphite, and also in the use of machinery. When the graphite is taken from the mines, it is reduced to a powder, and then separated into various grades according to fineness. This separation is effected by running the graphite, with a current of water, through a series of tubs, each one set above the other. The coarsest settles in the first tub, the medium in the second, and the finest (which is used in the best grade of pencils) in the third. The graphite is then mixed with a fine quality of porcelain clay, and the mixture is thoroughly ground between flat stones. It contains enough water to give it about the same thickness as cream. The clay determines the grade of hardness in the pencil; the greater the proportion of clay, the harder the lead. Ordinary writing pencils contain about equal proportions of clay and graphite.

After grinding, the water is forced out of the mixture by hydraulic pressure. It is then made



THE JOSEPH DIXON CRUCIBLE CO., AND THE EAGLE PENCIL CO., ARE THE TWO GREATEST PENCIL MANUFACTURERS IN THE UNITED STATES.



SCENE IN JOSEPH DIXON CRUCIBLE COMPANY PENCIL FACTORY SHOWING PLANING

directly into leads. These leads are made by a machine which works on the principle of an old-fashioned force pump. It contains a close fitting iron piston which is forced into a cylinder with a screw. The bottom of the cylinder contains a small round hole, the diameter of the lead desired. As the piston works its way down the cylinder, the lead is forced out and coils up like a wire on a board at the bottom. It must now be handled with skill and dispatch for it dries rapidly. It is quickly cut into lengths sufficient for three pencils and straightened on boards. These leads are then gathered in bundles and baked until they become thoroughly dried and hardened. They are then ready for the cases.

In cheaper grades of pencils the cases are made from pine; in medium grades, of common red cedar, but the best grades have their cases of the finest quality of red cedar, obtained in the Florida Keys. The wood is prepared for the pencils where it is cut and comes to the factory in the form of little blocks, seven inches long, three and a half inches wide, and three-eighths of an inch thick.

When the blocks reach the factory, they pass through a peculiar planer which cuts and polishes the grooves for the lead. Each block contains grooves for six pencils. They are then passed to a bench, where the filling is done. One workman places the lead in the grooves,

another glues them and a third places the blocks together. The filled blocks are placed in a strong press where they remain until the glue is thoroughly dried. The ends are then smoothed and they are passed through another peculiar planer which cuts them into individual pencils.

The best grades of pencils are usually stained and varnished, all of which is done by machinery. As the pencils pass from one department to another, they are counted to see that no loss occurs. The counting is done by dropping them on to a board having grooves or notches. Each board is made to hold 144 pencils. By filling his hands with pencils and running them rapidly over this board, a workman can count a gross in five seconds of time.

The Joseph Dixon Crucible Co., and the Eagle Pencil Co., are the two greatest pencil manufacturers in the United States. Nearly all the pencils of note or value which we use are made by one or the other of these firms. In style of finish and degrees of hardness, they have varieties sufficient to meet all demands. The degree of perfection to which the lead pencil has been brought makes it the cheapest, pleasantest, and most convenient writing instrument in use.

Colored pencils are made by coloring clay and making it into a composition which can be used as lead in the common lead pencils. Nearly all shades and colors can be obtained if one desires

them. Another peculiar pencil made by these firms is one used in marking on glass and china. What we call the lead, consists of a mixture of lampblack, graphite, and wax. When these pencils get cold they become so brittle that they can not be used.

PENS

Before the invention of pens, reeds, the stylus, and brushes were used for instruments of writing. The first pens were undoubtedly made from turtle shells, bone, and similar material. It was found later that quills of certain birds, like the goose and crow, were better adapted to this purpose, and quill pens came into general use. It is from the Latin word meaning feather that we get the word pen. The quill pen was the favorite writing instrument for several centuries. While it may seem to us that only coarse writing can be done with it, we find specimens of beautiful work made with these pens in the hands of skillful writers who lived in the 12th and 13th centuries. Many of the books written before the invention of printing were done with quill pens. The writer manufactured his own pens, using a knife with a small, sharp blade for this purpose. The beauty of his work depended very largely upon his skill in making his pen.

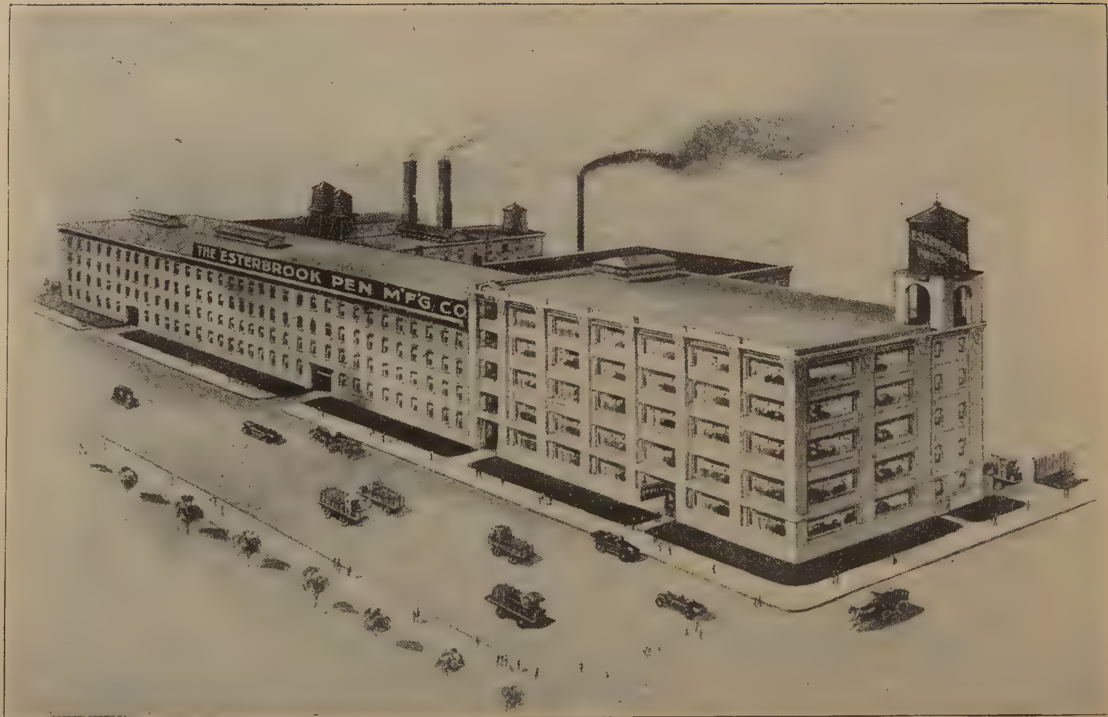
The metal pens were undoubtedly made by rolling metal in the form of a tube and then

pointing and shaping it at one end in the form of a pen; the remainder of the tube served as a handle or holder. Later the handles were made of different materials and the pen was of sufficient length to insert in the holder. The invention of the steel pen as it is now known, is uncertain. It is claimed by several manufacturers, but no one has been able to prove which claimant produced his invention first.

As the pen is a delicate instrument, its manufacture requires care and skill. Steel used for this purpose is rolled into sheets about six feet long and seventeen inches wide. These sheets are cut in strips and placed in air-tight boxes, where they are heated to a dull red and then allowed to cool gradually before being taken out. As the heating forms blisters on the surface, the pieces are washed in a weak solution of sulphuric acid to make them smooth again. After the washing, they are rolled in a barrel with pebbles and water. The strips are again rolled to the required thickness for the pen. This work must be delicately done since the variation of one thousandth of an inch in thickness spoils a plate.

The plates are now prepared for making pens. The first process is stamping or cutting. This is done by dies which cut the pens from the strips. The pieces cut out, called blanks, are shaped like a pen, but are still flat. They are then stamped

RICHARD ESTERBROOK, AMERICA'S FIRST PEN MAKER



ESTERBROOK PEN MANUFACTURING COMPANY, CAMDEN, NEW JERSEY

with the name and grade at the same time that the points are hammered. From the stamping machine they pass to the press where the pen is punched. The little opening thus formed near the point is necessary to make the pen elastic, and also enable it to hold ink well. After again washing, to remove dust and grease, the blanks are heated once more in iron boxes to a dull red. When cool, they are rounded into the shape of the pen by pressing in dies.

The pens are tempered by heating them to a bright red, and immersing in vats of oil. The immersion is done with buckets which are perforated in the bottom. As the bucket rises from the vat, the oil rapidly drains out. This cools the pens so rapidly, however, that they would be altogether too brittle for use, so they are again washed in boiling soda water and tempered by being rolled in cylinders over a charcoal fire.

After annealing, the pens are rolled for several hours in a barrel of ground iron and then in another of dry saw-dust. This completes the polishing process, and leaves them a bright silvery color. The points are now ground and finished, and the pens are ready for the last process, which is slitting the point. We notice how perfectly the edges of this slit fit together, and how easily the pen spreads when we bear upon it, but we seldom think that this result is brought about by polishing the edges of this slit.

This polishing is done by tumbling the pens for several hours with powdered iron. Those pens that have a brown color are bronzed to prevent them from rusting. All those of the first quality are carefully examined by girls, who become very expert in their work. All imperfect pens are rejected. Those suitable for use are packed in boxes holding one gross each.

There are only six important pen manufacturers in the United States, but the pens from these are found in the stores of all stationers. Varieties and styles are sufficiently numerous to meet all demands and cater to all tastes. England is the leading nation in the world for the manufacture of steel pens. In the city of Birmingham, nearly 50,000 persons are employed in pen factories, producing on an average 25,000 gross of pens each week. It requires at least a ton of steel of the best quality to make 1,000,000 pens; and, strange as it may seem, it is nevertheless true, that more steel is used every year in making pens, than is consumed by all the gun, sword, and needle factories of the world. This plainly shows us that the "pen is mightier than the sword" in more senses than one.

Steel pens of excellent quality can be purchased at any stationery store, at from fifty to seventy-five cents a gross, but the first gross of steel pens sold in England in 1820 cost the buyer a sum equal to $36.00 in our money. The quality

of those pens was not as good as that of pens to-day, which can be bought for thirty-six cents a gross. This improvement in quality and cheapening in price is all due to the invention and perfection of machinery now used in pen manufactories.

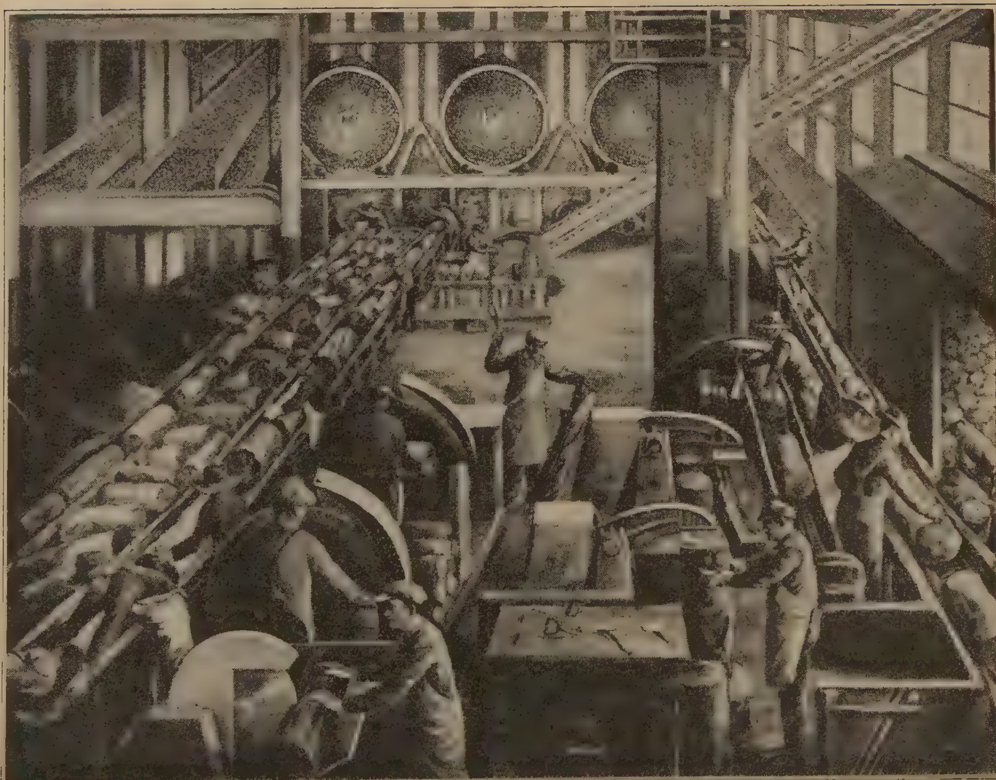
While England is the leading nation in the production of steel pens, we find the United States stands at the head as the producer of gold pens. Most of the gold pens made in this country are sold in Great Britian, France, and Germany. As the gold, even with the alloy, is so soft that the points wear rapidly, they are protected by what is called the diamond point. This simply means that a small quantity of harder metal, usually iridium, is inserted at the point of the pen.

PAPER

THE wasp was the first papermaker, and his material was the same as that employed by the largest paper mills of today, namely, wood fiber. The celebrated Egyptian scholar, Dr. Ebers, tells us that our word paper is derived from *papyrus;* our word Bible from *byblos,* the Greek name for the papyrus plant and the writing material prepared from it, and that the Greek word *bybleon* is applied to both.

There are several varieties of the papyrus plant, but that from which a substitute for paper was first made is the Papyrus Antiquorum, and is of genuine African origin. The plant was abundant on the banks of the lower Nile during the days of the Pharaohs, but it is now found only in the regions of the upper Nile, in the country of Abyssinia, and still further inland. It

OXFORD PAPER COMPANY, RUMFORD, MAINE



Courtesy Oxford Paper Co.

grows in dense thickets, and often attains a height of twelve or fifteen feet.

Authorities differ about the method of treatment this plant was subjected to by the ancient Egyptians in making what was their paper. Some say that they took the thin inner bark and laid the strips together so they would overlap. Then, by rubbing, the sap would cement these strips into a sheet, which when dry would retain its form. Others think the leaf of the plant was used instead of the bark, and treated in a similar manner. Probably both methods were used, and in this way the papyrus rolls were made, upon which were written in hieroglyphics the biographies of the kings of this ancient people. Many of these rolls have been discovered and translated in recent times and have revealed many interesting facts about the Egyptians and their government.

The Chinese are supposed to be the inventors of paper as we know it. Cotton was the material which they used. Paper made from linen rags is first known in an Arabic manuscript bearing the date of 1100 A.D. It seems that the Persians and Arabians learned the art from the Chinese, and later gave it to the nations of Europe. The first paper mill in Europe was established in Germany late in the 13th century, and during the next three hundred years paper-making became general over the continent

France and Holland taking the lead in the industry. But little paper was made in England previous to the reign of Elizabeth. The Dutch were the first to make use of machinery to macerate the rags into pulp.

The first paper mill in America was built by William Bradford and William Rittinghuyser on the banks of a little stream, still known as "Paper Mill Run," near Philadelphia, in 1690. The structure was of coarse unhewn logs, after the style of the buildings of that time.

"As paper has been the medium by which learning and culture were transmitted, so was the idea of the manufacture of paper borne on the winds of commerce, so have the highest art and skill entered into its manufacture." From the old mill on the banks of Paper Mill Run the industry has continued to grow during the three centuries of its existence, until paper-making now holds the fifth place among the industries of the country.

For several centuries all paper was made by hand labor. The process was very slow, and the product a paper of very inferior quality. The paper used for making books during the 16th century was of a much poorer quality than most of that now used by grocers and other merchants for the purpose of wrapping their goods.

The rags were shredded and churned until they were reduced to pulp which could be made

into paper. The pulp was kept floating in large vats from which it was dipped as needed. The pulp was dipped out by a square dipper, called the "mold." This dipper had a long handle and a bottom of wire cloth. It was also fitted with a thin frame called the "deckle." The deckle was just the size of the sheet of paper. The workman put this on the mold and dipped them into the vat. A thin layer of pulp covered the mold inside the deckle, and by gently shaking the dipper this was evenly distributed over the wire cloth. As the dipper was raised from the vat the water drained off, and the mold was taken from the deckle and passed to another workman called the "coucher." The coucher spread a sheet of felt cloth and turned the mold over so as to lay the pulp flat upon it. As these formative sheets of paper were taken from the mold they were laid upon felt and piled upon one another until the pile contained 130 sheets.

The pile was then placed under a hand press which squeezed out most of the remaining water. The felts were then taken out, and the sheets of paper pressed again by themselves. They were then separated and pressed a third time, after which they were hung on lines to dry, very much after the manner of hanging the washing in the backyard. After drying, the sheets were sized by dipping them in a thin solution of glue and alum. Then they needed to be

pressed again, after which they were dried for several days. The final finishing was done by passing them between hot metal rollers which were highly polished, or by pressing them between glazed pasteboard and hot metallic plates. The surface of this early paper was uneven and difficult to work on. The process seems to us very crude, and we may wonder that paper could have been made by it at all. Still, however complex the process of paper-making may seem to-day with the elaborate and expensive machinery employed, the modern paper mill is only a device for carrying on the old process of the hand mill on a larger scale and in a more perfect manner.

Any vegetable fiber which can be reduced to a pulp can be made into paper, but the quality of the product will depend very largely upon the material used. Straw, hemp, jute, etc., when used alone, will make the coarse heavy paper used in wrapping merchandise, while linen and cotton rags make the finest grades of writing and printing paper.

The best grades of paper are made entirely of rags, but most of the ordinary grades contain other and cheaper material, such as wood pulp, straw, and hemp. The best quality of rag paper must contain a fair proportion of linen, but it is not all linen. In fact, the only pure linen paper used is found in bonds and bank notes. Linen

paper writes well, but is stiff, crackly, and difficult to fold, as well as expensive. For these reasons a mixture of cotton and linen makes a more desirable writing paper. The proportions are usually two parts cotton to one linen.

The first step in making rags into paper is to shred them. All buttons must be taken off, and all seams ripped out in order that they may be thoroughly cleaned. After shredding, the rags are treated to a quantity of chloride of lime and steamed for several hours at a high temperature in a closed boiler. The chloride of lime serves the double purpose of a bleaching and a cleansing agent. When the rags emerge from this process, they are white and clean. They are then thoroughly washed and taken to the beating engine, which does the grinding, or reduces them to pulp. These engines consist of a rapidly revolving axis filled with sharp knives, and encased in an oval-shaped vat. The shaft containing the knives extends about half way across the vat in the direction of its shortest diameter. On the other part of the shaft is a drum cylinder covered with wire gauze. A stream of water is admitted at one end of the oval, and carries the rags under the knives. After they have passed through, the cylinder hurries them around the vat for a second grinding, and so on as long as the process is continued. In course of the grinding the pulp usually passes through three

engines, each reducing it finer than the other. In its final stage the pulp bears a close resemblance to rice and milk. From six to eight hours are required to complete the grinding, and the pulp passes from the last engine directly to the storage vats, from whence it is pumped to the machine that converts it into paper.

The machine known as the "Fourdrinier Paper-making Machine" is the most complete and perfect apparatus yet invented for the manufacture of paper. The machine is very large, sometimes having a length of 150 feet. It is also a complicated structure, and difficult to understand without seeing it in operation. So perfect is the adjustment of the parts, and their adaptability to the work in hand, that one of these machines seems to exercise almost human understanding in performing its task. This is to receive the pulp at one end as it comes from the storage vat, and turn out at the other end the paper finished and ready for use. Let us try to follow the pulp as it passes through the machine in its transformation to paper.

The pulp is pumped from the storage vat into a long narrow box at one end of the machine. From this box it flows through a pipe and spreads itself over a frame set with horizontal slats about an inch in depth. The grooves between these slats catch any sand or pieces of metal that may have followed along. Next

Courtesy Oxford Paper Co.

PAPER MAKING MACHINES

SORTING OLD RAGS

Courtesy Bryant Paper Co.

COUNTING AND BUNDLING

comes a sieve of brass wire which removes any threads or knots that may have escaped the engine. From a box beneath this sieve the pulp falls upon an endless belt of wire gauze. This belt is about thirty feet long, and is supported on numerous rollers. It also has a lateral as well as a longitudinal motion. This is for the double purpose of keeping the pulp evenly distributed over its surface and weaving the fiber together so as to give greater strength to the paper. Running along each side of the gauze belt are two rubber straps, supported in a frame known as the "deckle frame." These straps perform a function similar to that of the original deckle in the old hand mill: viz., to confine the pulp between them and determine the width of the sheet.

As the pulp passes along over the gauze, most of the water is drained off. Just before it leaves the wire it passes over a vacuum box from which the air is partially exhausted by pumps, and this serves to remove more moisture, and make the substance firmer. As the sheet leaves the deckle, it passes over a wire roller known as the "dandy roll." This serves to still further press out the water, and to stamp any impression which the manufacturer may desire to place upon the paper as a trade-mark. This impression is known as the "water mark," and can be readily seen by holding the sheet between the observer

and the light. It is found only upon paper of good quality, and is a guaranty of its grade. The design is made of wire, and fastened upon the roller, so that an impression is made at each revolution. If no impression is desired, the roller is left plain. This arrangement strengthens the impression made by the wire gauze, and the paper is known as "wove." "Laid" paper is distinguished by having parallel lines running through it at equal distances. These are made by fastening wire around the surface of the dandy roll. Some of the devices stamped in this way have given different kinds of paper their names. Foolscap was so named because when that kind of paper was first made it bore the water mark of the jester and his bells.

Between the dandy roll and the end of the belt of gauze there are several suction boxes which still further remove the moisture and strengthen the sheet. After passing these boxes the paper leaves the belt of gauze and passes to one of felt, and known as the "wet felt." This belt takes it between the first "press rolls." From these the paper is carried to the second "press," where it is transferred to another endless felt which takes it on its way to the driers. The paper is now practically made. The further work of the machine consists of drying, sizing, and finishing.

The driers are large iron cylinders about two

and one-half feet in diameter. They have highly polished surfaces, and are heated by steam which enters through the trunnions upon which they revolve. The machine is so constructed that the number of these cylinders can be increased indefinitely, and their number depends to quite an extent upon the grade of paper which the machine is to make. On its way over the driers the paper passes through a vat of sizing, and again between a pair of press rolls, to have the unnecessary sizing removed. The best grades of paper are obtained by allowing it to dry slowly after sizing, so the entire fiber may receive a portion of the finishing solution. For this purpose a large number of driers at a low temperature is required.

After being thoroughly dried the paper is passed over and between a set of press rolls each of which is about a foot in diameter, and placed one above the other. This part of the machine is known as the "stack," and its work is to polish and finish the surface. Paper made by a machine having this attachment is known as "calendered" paper.

From the stack the paper goes to the reel or cutters as desired. That used by the great newspaper houses is rolled and printed directly from the roll. That used in printing most books and magazines is cut into sheets and put up in quires. This style of marketing is used with all

paper of high grade, such as stationery and the best qualities of printing paper.

From this description it will be seen that the Fourdrinier machine does on a large scale, and in a better way, what the mold, the deckle, and the press did in the old hand mill. Each machine is constructed for the particular kind of paper which it is to make, and can not make any other economically. The part of the machine which requires great skill in adjusting and tending is that over which the pulp passes before reaching the driers. Any fault in the flow of the pulp at once destroys the symmetry of the sheet, and usually causes it to break and run to waste. The machine is seldom stopped when an accident of this kind occurs. The attendant soon effects the necessary adjustment, and the paper ribbon rolls on. One of these machines will run thirty feet of ordinary newspaper a minute, and sixty tons a week by working twenty-four hours to the day.

The Civil War put a stop to the importation of rags for several years, and, for a time, papermakers were unable to supply the demand for their product. Finally, someone conceived the idea of treating rye straw to the same process as rags in the manufacture of the pulp. The experiment was so successful that nearly all the newspapers during the four years of the war were printed on straw paper. Wood gradually came

to take the place of straw. The inner bark of the basswood had been used to a limited extent in paper-making for a number of years, and this led to the use of the wood itself.

At first, basswood was the only sort considered suitable for pulp, but now the processes of manufacturing wood pulp have been brought to such a degree of perfection that pine and spruce are very generally used. The wood is prepared for paper by two processes. The pulp is made by grinding, and what is known as "fiber" by chemical action.

In the manufacture of pulp, the wood is first stripped of its bark, after which it is cut and split into blocks resembling stove wood. The knots are removed from these blocks, and they are then ready for the grinder, which is a large grindstone revolving on a horizontal axis. The stones revolve at a high rate of speed, and the wood is pressed against them by the action of a screw which is operated from the axis. A stream of water flows over the stone, and carries away the pulp as fast as it is ground. The pulp passes over a wire screen which removes all splinters and knots, the fine pulp being sucked through the screen by a bellows-like arrangement attached to a box underneath.

After screening, the pulp, as a rule, is pumped to the "wet machine," where it is gathered on an endless woolen felt, and pressed into layers, or

"laps." The laps are about two-thirds water, but make quite a compact sheet, having the thickness of ordinary pasteboard. If the paper is made in a separate mill, the laps are shipped to the consumer. Most large mills, however, grind their own pulp, and thus save a good deal of freight.

Spruce is considered the best wood for pulp. A cord of good spruce will produce a ton of pulp, dry weight. About 200 horse power is required to grind three tons of pulp in twenty-four hours. The development of pulp machinery during the past few years has been extensive, and has engaged the attention of some of the most competent inventors and designers.

It was soon discovered that there was not enough fiber in wood pulp to give paper sufficient strength to withstand the strain of the printing press, and a proportion of rag pulp had to be added. A process of treating wood has now been perfected by which the fiber is preserved so that paper can be made wholly from wood, and contain the necessary qualities for successful printing. Wood fiber is prepared by cutting the wood into chips and packing these in a large boiler, called the "digester." A solution of caustic soda or sulphate of soda is added. The digesters are then closed and the contents cooked for eight or ten hours under a steam pressure of ninety or one hundred pounds.

Courtesy Oxford Paper Co.

COATING PAPER

COATED PAPER IN DRYING ROOM

Courtesy Bryant Paper Co.

PUTTING UP SHIPPING ROLLS

When the "cook" is completed, the contents of the boiler are washed and made into laps the same as those from the pulp. In making the paper the fiber and the pulp laps are mixed in proper proportion in the engine.

Nearly all the paper used by the large newspapers is made from wood, and more or less wood enters into the composition of that used in printing books. But paper containing any considerable amount of wood turns yellow or brown when exposed to the light, and should not be used for printing matter which is to be preserved for any length of time. The rapidity of the process of making paper from wood is astonishing. Excepting the chemical process necessary for making the fiber, a tree could be converted into paper in an hour.

The coarsest kinds of wrapping paper, and the board used in the manufacture of paper boxes, are made from wheat straw. The pulp is prepared by first boiling the straw with quicklime, then washing and reducing in the beating engine. This paper is finished in a cylinder machine working on the same plan as that already described, though of much simpler construction.

Other substances which can be used to advantage in the manufacture of paper are bamboo, corn husks, and esparto grass. This grass grows in the southeastern part of Europe, and has an

excellent fiber. It is cheap and abundant, and is extensively used in the paper mills of England and the United States. One of the most important considerations in the manufacture of material is that of the selection of the fiber. The most perfect spinning fibers, and the best for paper-making, are cotton and flax. Next to these are shea, the fiber of the so-called China grass, cultivated extensively in the East Indies, hemp, jute, and, after these we may rank the fibers used in twine and rope-making, but not adapted to spinning. The poorer the fiber, the poorer the quality of paper. The chemical composition of the fiber, or its capacity for withstanding the natural agencies of destruction, is also an important requisite of the material used. In this respect cotton and linen rags are the best, and wood fiber is the poorest.

There are many special kinds of paper bearing distinct names, such as India paper, Japan paper, etc. Some of these names indicate the place of manufacture, while others refer only to the quality or use. The delicate operations necessary to the manufacture of some of these brands is especially noticeable in connection with silver tissue paper. This is so thin that we can scarcely measure its thickness, yet it is quite strong. Much of our tissue paper is made from old rope, which shows the good use that can be made of what we might at first consider worth-

less material. On account of the strength of its fiber, rope is especially adapted to the manufacture of thin paper. Many of the smooth papers have their pores filled with a preparation of fine porcelain clay, or talc. Glazing and polishing give such papers or boards a smooth, glossy surface, especially suited to certain kinds of writing and printing. For engravings a paper with a fine fiber but slightly rough surface is usually preferred, as this brings out the details of the picture in clear relief.

There are many sorts and grades of paper. These have different names in different countries, and each class has its numerous subdivisions which are recognized in trade. All these, however, can practically be classed under the following heads: printing, writing, wrapping, and boards.

The following sizes are among the most common, and are in general use. The sizes are given in inches.

Billet note	6x8
Cap	12¾x16½, and 13x17
Commercial letter	11x17
Commercial note	8x10
Letter	10x16
Octavo note	7x9
Packet note	9x11½
Small flat cap	13x16

The size of the pages of a book or pamphlet is frequently denoted by the number of folds in the sheet, showing the number of leaves.

Folio, folded once	2 leaves, 4 pages.
Quarto, folded twice	4 leaves, 8 pages.
Octavo, folded four times	8 leaves, 16 pages.
Duodecimo, folded six times	12 leaves, 24 pages.

Sixteen is the highest number of folds usually made in book-making; this gives 64 pages, and is styled a 32mo. This book is an octavo, having 16 pages to the sheet.

We are all familiar with common uses of paper, and they do not need any special mention in this work; but, if the new discoveries of the uses of this article are any index to advancement in civilization, we must be making progress very fast. Some of the most recent and novel uses to which paper pulp has been put are making window panes, flower pots, wagon wheels, horse-shoes, barrels, tubs, pails, pulleys, etc. Flower pots are made from 85 parts wood and 15 parts rag pulp. The pot is shaped to the desired form in a mold. After drying, it is subjected to the treatment of a composition consisting of a petroleum, paraffin, and linseed oil. The liquid is put on hot, and permeates the entire substance and renders it water-proof. Paper is also used in the construction of canoes, and in building portable houses. It is light, strong, and durable, which

qualities adapt it to the construction of portable hospitals, and such other buildings as are necessary to the field outfit of an army.

The older paper mills are located in the New England and other eastern States. The most noted mills of the country are at Holyoke, Mass., Bellows Falls, Vt., and Ticonderoga, N. Y.; but the use of wood in the manufacture has caused the erection of many large mills in the vicinity of the forest regions, as it is much cheaper to freight the paper than the raw material. The perfection of machinery by which the expense of manufacture has been greatly reduced has proportionately extended the use of paper, as it has enabled publishers to reduce the price of books and periodicals to such an extent as to make it possible for everyone to purchase them. This, with the new uses for paper which are being continually discovered, cause such a demand for it that the United States has become the largest paper-producing country in the world.

PRINTING

FRANKLIN PRINTING PRESS

BY PRINTING we mean the art and process of stamping the impression of letters, figures, and designs upon some surface, usually that of paper or cloth. Books and papers are so common that we naturally, and rightly, too, associate the art of printing with their production. But in its fullest sense printing means more than this; it includes the stamping of patterns on certain varieties of cloth and the production of engravings, half-tones, and several other styles of pictures.

HISTORY

Like many other arts which are common to-day, printing began in a very rude fashion, and among ancient people. The Egyptians engraved characters and symbols upon tiles and

cylinders, and impressed these upon soft clay tablets which were then hardened by baking. Layard, the celebrated English traveler who excavated the ruins of ancient Nineveh and Babylon, says, "The most common mode of keeping records in Assyria and Babylon was on prepared bricks, tiles, or cylinders of clay, baked after the characters were impressed. These impressions were probably made by the use of stamps, the characters used were triangular, and from this fact the writings of these people are known as "cuneiform," a term which means wedge-shaped. The ancient Babylonians preserved thousands of tablets covered over with such impressions, and these constituted their libraries.

The Chinese have practiced the art of printing for centuries, but in this as in other industries, they have made little or no progress. They now print as they began; that is, from blocks, each of which is carved in relief so as to produce the printed page, and all the work is done by hand.

Some authorities believe that the Romans knew of the art of printing, but were afraid to use it, as the scattering of intelligence broadcast might cause the people to rebel against the government. Others think that printing was not practiced in Europe for a long time, because there were no suitable materials upon which to print. Be this as it may, we know that at an

early date the Roman emperors had stamps and signets which they affixed to public documents as seals. Some of these signets contained the initials of the emperor.

Several centuries passed between the beginning of Chinese printing and the use of Roman stamps, and printing with movable type, as we know it to-day. Dugald Stewart, an English writer, says, "Printing should be considered rather as the result of general causes, on which the progress of society depends, than as the simple effect of a happy chance." As we see the long struggle of this art to reach perfection, and the slow progress which it made during the first few hundred years of its existence, we are inclined to think that Mr. Stewart is right.

Engraving upon wood was the first step toward printing in Europe. Blocks were engraved for printing playing cards as early as the 14th century. The engraving of scriptural subjects with texts followed. The "Poor Man's Bible" was printed in this manner, and was a celebrated publication in its day. It contained about forty leaves printed from as many different blocks. It is believed that some of these leaves, and portions of two other books published at about the same time, were printed from movable type.

There has been much dispute over the inventor of printing with movable type. The Dutch claim that one Laurens Coster was the inventor, while

the Germans maintain that it was Johann Gutenberg, of Mentz, and the Germans are probably right. Gutenberg was the first to cut types from metal, and, later, he made matrices or molds, in which the types were cast. We do not know the exact date of Gutenberg's invention, but it was between 1424 and 1448. Gutenberg was an obscure German, but possessed some property. Some say that he expended it in the perfecting of his invenion. However this may be, John Faust, a wealthy goldsmith of Mentz, was associated with him in perfecting his type and presses, and carried on the business in company with his son-in-law for some years after Gutenberg's death.

Gutenberg's first book was a copy of the Latin translation of the Old Testament, and was printed between 1450 and 1455. This book is known as the "Mazarin Bible," because many years afterward a copy of it was found in the library of Cardinal Mazarin, in Paris.

Faust cut his type to imitate the script of the pen-written books of his day, and it is sometimes difficult to tell whether one of these old books was printed or written. For a number of years the art of printing was the secret of Faust and his co-laborers, and was confined to the city of Mentz. But the capture of the city by Count

Adolphus, of Nassau, in 1462, scattered these workmen, and they soon established their trade in other cities.

Faust printed Bibles, and offered them for sale in Paris for sixty crowns a copy, when a manuscript copy sold for 500 crowns. He astonished the people, not only by the low price of his books, but by the rapidity with which he could produce them. He increased the quantity, and even lowered the price. The uniformity of the books was also a wonder, as the pen-written, or manuscript, books, all differed from each other in appearance. Faust was accused of being a magician. It was thought that the red ink which he used was his blood, and he was solemnly proclaimed to be in league with evil spirits. In order to save himself from a bonfire he was obliged to reveal his art to the Parliament in Paris. He was released from all persecution on account of the wonderful invention which he disclosed.

Within eighteen years after the capture of Mentz there were ninety-four printing offices in operation in the different cities of Europe. William Caxton introduced the art into England in 1474 or 1475, and printed the "Game of Chess," which was the first book printed in London. Presses were soon established at Oxford, St. Albans, and Cambridge. At the close of the century there were in all 220 establishments in

operation, and every important city in Europe had its printing office.

The first printing press in America was set up in the City of Mexico, in 1569, and the first press in what is now the United States was placed in Harvard College, Cambridge, Mass., in 1639. It was procured by subscription and given to the college together with a font of forty-nine pounds of type. This may be considered the beginning of the now famous University Press, which is one of the largest and most noted book-making establishments in America.

William Penn established a press in Philadelphia in 1686, and one was started in New York six years later. In 1800 Philadelphia had 110 presses in operation, which was a greater number than could be found in any other city except London.

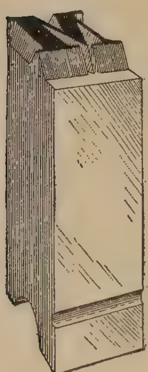
The first book printed in America was from the press in Mexico and was entitled "A Spiritual Ladder to Ascend to Heaven." The old press at Cambridge is of great historic interest. The first issue from this press was the "Freeman's Oath," the next was an almanac. But the most famous work of the press was the first edition of John Eliot's Indian Bible. The type was set wholly by an Indian, and the book was three years in going through the press. This was the first Bible printed in America. Only two or three copies of it are now in existence, and

these are valued at nearly $2,000 a copy. Books were first printed in Boston in 1676 and the Boston News Letter, 1704, was the first regular newspaper in the colonies.

From such small beginnings printing in the United States has grown to its present proportions, and is now one of the most important industries of the country, employing thousands of workmen, and having many millions of dollars invested in the buildings, machinery, and other printing material.

PROCESSES

The first step in printing a book or paper is setting the type, or composition, as the printer terms it. In order to understand what composition really is, we need first to know something about the type.



A type is a piece of metal, with the letter or figure cut on it in relief, that is, the letter is raised above the rest of the metal, so its surface is the only part of the type which touches the paper. When printing was first invented, the types were cut from wood, but they were soon cast from metal. Each printer made his own type. He had a small hand mold into which the melted metal

was poured, and so cast the type. You will see at once that it was necessary for him to have as many molds as he needed characters, and that type-making by hand was a slow process. As the printing industry increased in importance, type-making, or type-founding, became a separate business. Machines were invented which take the place of the old hand mold, and cast the type much faster and cheaper.

The mold in one of these machines will make only one character, the same as the hand mold, but it is of much better construction, and does more perfect work. The important part of this mold is the matrix or the part which casts the letter. The matrix is made by first making a steel die the exact model of the type, then driving this into a piece of soft copper until a perfect pattern of the character is formed. The matrix is then fitted to the mold, which is attached to the machine. The type-casting machine simply opens and closes the mold, filling it each time with melted metal. After leaving the mold the type is polished on a smooth stone, and put up in packages for use. Each package is made up of a large number of the same letters or figures. One machine will make about 30,000 ordinary sized type in a day.

Type-metal is an alloy of lead and antimony, with sometimes a little tin, nickel, and copper. This alloy melts easily, hardens quicklv on cool-

ing, and wears well. All type, whatever the size of the face, is of the same height. Type in the United States is made practically an inch high. The bottom and back are grooved. The groove on the bottom is to enable the type to stand firmly on its base, and that on the back to enable the compositor to place the type in correct position without looking at the letter.

There are thirteen sizes of type usually recognized in book-printing. The eight sizes in most common use are given in the illustration. These have for a long time been distinguished by peculiar names. The smallest being called "brilliant," and the largest "great primer." American type-founders, however, now denote the size of type by mentioning the number of points in the diameter of the letter. A point is $\frac{1}{72}$ of an inch. The sizes in most common use for books are 12-point or pica, 11-point or small pica, 10-point or long primer, 8-point or brevier. Newspapers

Nonpareil—abcdefghijklmnopqrstuvwxyz.
Minion—abcdefghijklmnopqrstuvwxyz.
Brevier—abcdefghijklmnopqrstuvwxyz.
Bourgeois—abcdefghijklmnopqrstuvwxyz.
Long Primer—abcdefghijklmnopqrstuvwxyz.
Small Pica—abcdefghijklmnopqrstuvwxyz.
Pica—abcdefghijklmnopqrstuvwxyz.
English—abcdefghijklmnopqrstuvwxyz.

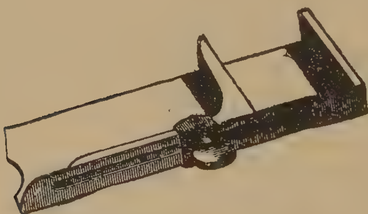
commonly use 7-point or minion, 6-point or nonpareil, and 3½-point or agate. This size is sometimes used in printing small Bibles. The smallest sizes are seldom used for an entire book or paper. They frequently occur in sub-heads, and always in marginal references in Bibles. This book is printed from 11-point or small pica. Job type is made in many sizes and styles. The largest sizes are made from wood.

A set of type containing enough letters for printing is called a font, and contains the requisite proportions of capitals, small letters, figures, and marks of punctuation. It also usually contains a small font of Italics. In all there are 225 characters for printing the English language. Each language requires a different number. The size of a font is determined by the work to be done with it, and varies from 500 to 25,000, or even 50,000 pounds. As we have seen, the font presented Harvard College in 1639 weighed only 49 pounds. Type-founders have a rule for determining the number of each letter necessary to make a complete font of any size. A font of 800 pounds of 12-point or pica will contain 3,000 small m's, 8,500 a's, 12,000 e's, and 200 z's.

COMPOSITION

The type is distributed for use in two cases; these are trays about 32 inches long, 17 inches wide, and 1½ deep. That for the large and

small capitals and figures is divided into 98 boxes, and the one for the small letters into 54 boxes. As some letters, like e, a, and m, occur much more frequently than the others, they occupy more space in the font, and are given correspondingly larger boxes in the case. The large boxes are so placed as to be near the hand. These cases are placed upon a frame about breast high, and having a top which slopes



toward the compositor. The case containing the capitals is placed on the highest part of the frame, and from their relative positions the cases are always known as upper and lower case.

The type-setter, who is called a compositor, uses a small frame of steel or brass to hold the type. This frame, called the stick, has a bottom back and two ends, being left open in front. Its depth is a little less than the height of the type. One end can be moved back and forth in a groove, and is held in place by a thumb-screw. By this arrangement the stick can be adjusted to lines of different lengths. The compositor holds the stick in his left hand, and picks up the type with the thumb and fore-finger of the right. Beginning in the lower left-hand corner of the

stick, the compositor places the type in position with the grooves in the body turned from him. In close printing one line of type is set against another, but in more open work a thin strip of metal, called a lead, is placed between the lines, and the work is said to be leaded. The words are separated by spaces, which are the length of

OLD-FASHIONED COMPOSING ROOM

the body of the type, and of various thicknesses. When a line has been set, the spaces are evened, or the line is "justified." When the stick is filled the compositor slips the type off on to a long

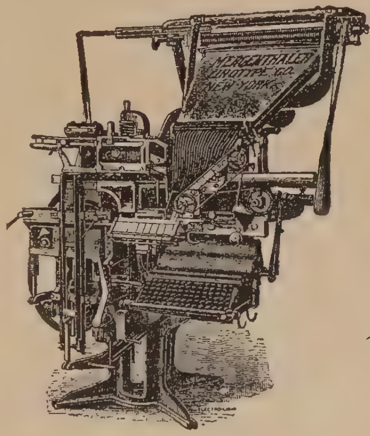
narrow frame called the galley, and proceeds with his work until his copy is all set. A stick will hold about fifteen lines of this type. Compositors are usually paid by the space. While all the type has the same thickness it varies in width. The M is about square, and is taken as the unit of measure for this space. The rate varies from 25 to 50 cents per thousand m's according to the size of type and locality, as different cities have different rates. A good compositor will set 800 to 1,000 m's per hour, of pica or nonpareil. The rate paid includes distributing the type, or placing it back in the cases after the printing is done.

After the type has been placed in the galleys, a rough print called the "proof" is taken. This is read by the proofreader, who notes all errors, and indicates them by marks on the margin. These marks are a series of signs, each one of which indicates the particular error to be corrected. The corrected proof is handed to the compositor, who proceeds to correct his type. A revised proof is then taken to see whether or not any errors still remain. Several proofs are usually taken of books and similar publications.

Type-setting machines are now in quite common use in large offices. A type-setting machine combines the type-casting machine with a device which places the matrices in the order desired by the compositor, so the type is cast as he

would set it from the case. There are several patterns of these machines, but that known as the linotype is the most complete and successful. This machine not only sets the type, but what is more remarkable, distributes the matrices.

The linotype was invented by Mr. Ottmar Mergenthaler, of Baltimore, and as it now stands, is the result of over twenty years of study and experiment. It includes the work of several other inventors, and is covered by over 1,400 patents. As one would naturally expect, the linotype is a complex piece of machinery, the most perfect pattern with all its attachments, containing over 3,000 pieces. The machine makes the type which it uses. It is operated by a keyboard similar to that of a typewriter. Each pressure of the key places the matrix for the required letter in the position which the type occupies in the line. When the line is filled, an automatic device spaces the words, the operator



LINOTYPE

then touches a lever, and the set matrices are carried to another part of the machine where the line of type is cast. As soon as the metal hardens, the machine releases the matrices, and returns them to their cases, to be reset, while it

MODERN COMPOSING ROOM

places the line of type in its proper position in the galley. While the machine is doing all this, the operator is setting another line, so that the work goes on without interruption. By the linotype the casting is done in lines, instead of single letters; if an error should be made in the com-

position, a new line has to be cast, yet this requires much less time than would be needed to correct the same error in type set by hand.

The type set by this machine are not distributed, they are simply thrown into the melting pot, and the metal is used over again. A skillful operator with a linotype can set as much copy as five compositors can set by hand. The linotype is in use in every large newspaper office, and in many offices where books and magazines are published, and has been a means of greatly reducing the price of these publications. The monotype is another type-setting machine that is even more wonderful in its operation than the linotype. The monotype casts its type in single molds so that they appear in the galley in the same form as when set by hand. The advantage of the monotype is that errors can be corrected as readily as in matter set by hand, while in linotype composition the entire line must be reset.

After all corrections indicated in the proof have been made, a workman called the "stoneman" takes the galleys and makes them up into pages. This work is called the "make-up" or "imposition." It is done on a large table having a stone or iron top. After the type has been divided into lengths suitable for pages, it is kept together by winding a small cord

around what forms a page. This admits of their being moved along on the table, but they can not be lifted. Sometimes an unfortunate compositor or pressman drops a galley or page of set type, and it is said to make a "pi," but the *pie* is one that no one would care to eat, for it is made of a mass of type jumbled together in hopeless confusion. When such an accident happens, the type is usually sent to the foundry, for the labor of assorting is more expensive than the type required to make good the loss.

After the pages are all formed, the stoneman locks them into an iron frame called the "chase." The pages are arranged so as to be in the right order when the printed sheet is folded. At first the arrangement strikes one as peculiar, and it would be a difficult matter for anyone not a printer to place the pages in a right position. A number called the signature is placed at the bottom of the first page of each sheet to show its order in the book. When the arrangement is completed, the pages are firmly locked into the frame by using strips of wood and wedges. These constitute the "furniture," and the entire arrangement of type and frame constitutes a form. After locking, the stoneman takes a wooden block and mallet and proceeds to even the surface of the type. He does this by placing the block on the face of the type and striking it

lightly with the mallet. He then takes hold of one side of the form and raises it very carefully from the stone, watching for any loose type, as it will tend to drop out. If no type moves, the form is ready for printing.

The disposal of the forms now depends upon the plan for printing. In small offices, like those found in country towns and small cities, all composition of the office is printed directly from the type; but in large offices only jobs requiring a limited number of copies are printed in this way, electrotype or stereotype plates taking the place of the type, so that we need to know how such plates are made before we can fully understand the process of printing.

ELECTROTYPING

Electrotyping consists in making an exact reproduction of a page or form of type or engraving, by means of electricity. The face of the type is brushed with a thin coating of powdered graphite, and then pressed upon the surface of a wax tablet, which has been prepared for the purpose by having a quantity of graphite rubbed into it. The type is pressed into the mold the depth of the letter, so as to leave a perfect impression when the wax is removed. This impression is then carefully covered with a thin coating of powdered graphite to make it a conductor of electricity. Fine iron filings are then

dusted over it and the depressions are filled with a solution of copper, which you may recognize under the name of blue vitriol, or bluestone. The iron is immediately replaced by the copper and a thin film of copper is laid all over the face of the letters in the impression. The mold is now ready for electrotyping. It is placed in a tank containing a strong solution of sulphate of copper. The negative pole of a strong battery is attached to it, and a piece of copper, which is placed in the tank, is attached to the positive pole. The electric current deposits the copper in the solution on the surface of the mold, and makes a perfect reproduction of the face of the type in copper. The piece of copper on the positive pole is dissolved into the solution as fast as the metal is deposited on the mold. When the coating has reached the thickness of three-thousandths of an inch the process is stopped, the coating is removed from the wax and filled on the under side with melted type-metal, so as to make it about one-eighth of an inch thick. The plate is then placed on a standard, usually a block, to make it type high, and is ready for the press.

Printing from electrotype plates has many advantages over printing directly from type. The copper, being harder than the type metal, wears much longer without showing defects; there is no danger of accidents happening to

the type; much finer work can be done with the plates, and the type can be distributed at once for resetting; when more copies of the work are wanted, the plates can be placed in the form in a few minutes, and the printing done at little expense. Steel plates are made by a similar process, and are also now in use for the finest work, like printing engravings and bank notes. All books, magazines, and illustrations are printed from plates.

Stereotyping is a similar process in which type metal is used in place of copper, and the melted metal is poured into the mold and cast, instead of being placed on the surface by electricity. In stereotyping the mold is made of papier-mâché or plaster of Paris. Stereotype plates are chiefly used in printing large newspapers, like city dailies.

PRESS WORK

The press does the actual printing, or impressing the type upon the paper. The first printing press was simply a wooden frame for holding the form, and an upright screw. After the face of the type had been carefully covered with ink, and a paper spread over the form, a plank, called the platen was laid over it, and the form was shoved under the screw which was worked by a lever. As the screw was brought down, it pressed the platen firmly and evenly upon all the type in the form, and printed the paper.

The screw was then raised, the form withdrawn, the paper taken off, and the process repeated until the desired number of copies was printed.

The type was inked by using balls made by filling a leather covering with wool, or some other soft material. The ink was spread on a flat stone, and the balls were rolled over the inked surface and then against each other to distribute the ink evenly over them. They were then rolled and patted over the type until the entire form received its coating. This work was done by a boy. As can be easily imagined, some of the ink would occasionally get upon his hands and face. His appearance reminded his companions of the imps they learned about in the ancient legends; from this he was dubbed the "printer's devil," and the name has been given every printer's apprentice to this day.

This press was clumsy, difficult to work, and very slow. By dint of hard work only a few hundred copies could be printed in a day; yet it was the only press used for nearly three hundred years. Benjamin Franklin used one in London as late as 1725, and it is now in the United States Patent Office at Washington, as a national curiosity.

The development of the printing press has been in the perfecting of the machinery to do better, quicker, and more economically what was accomplished by the old screw pattern. The

Earl of Stanhope made the first real advance in improving the printing press. He constructed a press of iron which was a great improvement over the old screw press of that time. Stanhope's press had a spring attached to the screw so it would fly back and lift the platen automatically. He also improved the arrangement for moving the form. Stanhope's use of what is known in mechanics as the toggle joint, for working the platen, greatly increased the speed of his press, and the only important improvement to this invention has been the addition of a self-inking device. Presses of this pattern are still in use in many small towns for printing country newspapers.

The growth of the newspaper, and the constant demand for larger editions than the publishers could supply, spurred inventors to make a press which would print more rapidly and cheaply than anything that had been made. The result of this effort was the rotary or cylinder press substantially as we know it to-day. The first press of this kind was made by Friedrich Konig, a German, in 1814, and was used in printing the London Times. It made the wonderful record of 1,800 impressions an hour.

Konig's press was the forerunner of many based on the same plan, and which may be found in almost any good printing office. In a press of this pattern the paper is passed over the form by

a large cylinder which forms the platen. The form moves back and forth on a horizontal bed.

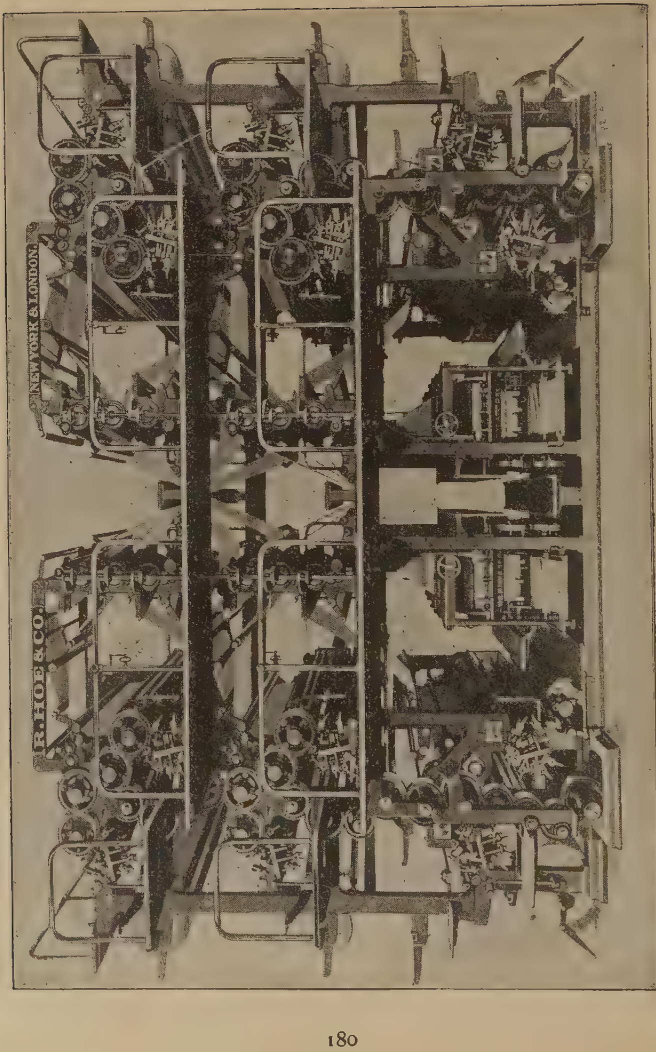
IN A PRESS ROOM

As the paper passes on to the delivery fly after it is printed, the form returns to the ink roller, which recoats it for the next impression. The

press is fed from a slanting table so placed that its lower edge almost touches the top of the cylinder. An automatic clamp attached to the cylinder catches the paper and holds it in position until printed. By constructing a double machine, Konig was able to print both sides of the paper without rehandling it.

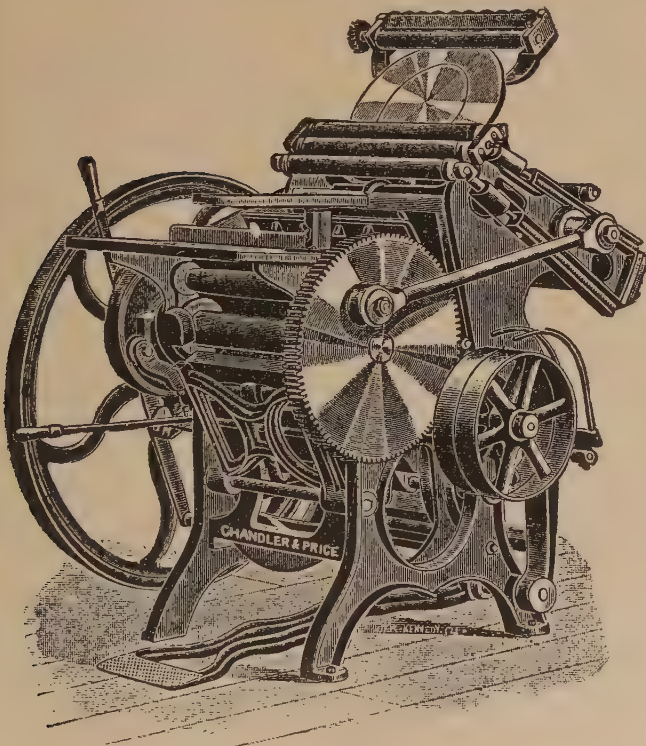
The next great advance was in the construction of a press which held the type on a revolving cylinder. While this machine was a very ingenious device, it was too delicate and complicated to be of practical use; it led, however, to the perfecting of presses with revolving type cylinders some years later, about 1840 to 1848.

The American press invented by Col. Richard Hoe, of New York, in 1840, is considered to be the first successful press of this pattern. This press, with various improvements that have been added from time to time, is the great newspaper press of to-day. Its plan is such that it can be constructed with as many cylinders as the size of the paper may demand. At first these presses were constructed with two, four, or eight cylinders. In 1850, an eight-cylinder press was constructed for the New York Sun, which printed 16,000 sheets an hour on one side. This was a great advance over any previous press, but there was demand for still greater speed, for the newspaper circulation was rapidly increasing. This



DOUBLE SEXTUPLE PRESS BUILT EXPRESSLY FOR THE NEW YORK JOURNAL

press printed the paper in single sheets, and required as many feeders as it had cylinders.



SMALL JOB PRESS

The Civil War caused such a demand for papers that it was next to impossible for the publishers to supply their customers. Up to this time stereotype plates had not been considered

practical for newspaper work on account of the time required to make them. This difficulty was now overcome, and this made possible the perfecting press, so called because it prints both sides of the paper while passing through the machine. Stereotype plates for this press are cast in molds which are in the form of a half-cylinder, so they can be readily clamped to the cylinders in the press. The perfection press can be constructed to print almost any number of papers at a time. Folding machines have been invented to attach to the press, and the entire combination takes the roll of paper at one end, and turns out the papers printed, folded, and counted at the other, and this at such a rate of speed that the most trained eye is unable to count the papers as they fall from the machine.

The rapidity with which the daily paper is printed on these presses is almost beyond comprehension. A press recently constructed for a large daily paper can print, cut, fold, and count 96,000 eight-page papers an hour, or 1,600 a minute. The paper runs through the machine at the rate of thirty-two and a half miles per hour, which is a speed greater than that of the average railway passenger train. The mechanism of this press is so perfect that the breaking of a narrow band of tape in the folder, the loosening of a nut, the bending of a rod, or any other slight disarrangement is instantly apparent

to the operator. These machines weigh on an average thirty tons, it requires about eighteen months to construct one, and its cost is more than would have been required to buy all the newspaper presses in the country at the beginning of the century.

Books and magazines are printed on both bed and rotary presses constructed expressly for this purpose. They have a much lower rate of speed than the newspaper press, and most of them print from sheets instead of rolls of paper. Self-feeders have now been invented, so that these presses are also automatic. Besides the different presses here described there are many patterns of smaller size used in printing circulars and doing general work in job offices. All of these show the ingenuity of the inventor, and contribute a great deal toward the success of one of the most important industries of the country.

NEWSPAPERS

AT ONE time it was the custom of the Roman Empire to send daily accounts of the imperial army to the generals in command in the different provinces. These accounts were styled "Acta Diurna," which means Daily Doings, and may be said to form the beginning of a systematic attempt to distribute news. Some centuries later the newspaper originated in Venice, where it was first known as the "Gazetta." There are several opinions as to the origin of this name. Some think it was taken from gazzera, meaning a magpie or chatterer; others, and probably with better reason, attribute the name to the Venetian coin gazetta, which was the common price of the paper. At all events, the term Gazette, which is now such a common title for

newspapers, is supposed to have originated from this word. The first paper was merely an organ of the government; the sheet was published once a month, and distributed in written manuscript, a custom which this paper followed long after the invention of printing, as the government did not wish the news it contained to be generally known.

The newspaper in England dates from the reign of Queen Elizabeth, though no regular periodicals were placed in circulation until the days of Cromwell, in the seventeenth century. Most of the early journals were extremely partisan in their statements, and often became a nuisance to the people. They were generally known as weekly news books, bearing such titles as "News from Hull," "Truths from York," etc. The animosities of some of these journals developed peculiar titles, as "The Scot's Dove Opposed to the Parliamentary Kite" or "The Secret Owl."

The American colonies had been settled nearly a century before any newspaper was established among them. During this early period of struggle, there was little demand for either books or papers among the colonists. Besides, the difficulties attending the establishment of printing in the colonies were very great, and made the business so expensive that it could not be carried on with profit.

The first English newspaper in America was Publick Occurrences, Both Foreign and Domestic, issued in Boston in 1690. The paper was immediately suppressed by the authorities of Massachusetts, and only one edition of it ever saw the light. The Boston News Letter of 1704 is consequently considered as the first real American newspaper. For fifteen years it was the only paper published in the colonies. In 1719, the Boston Gazette was started. The editors of all these early papers were postmasters, and the papers were the outgrowth of their custom of making a periodical summary of the news letters sent from London, and sending this to the governors of the surrounding colonies.

The first paper outside of Boston was the American Weekly started in Philadelphia in the same year as the Boston Gazette. The fourth journal was the New England Courant, established by James Franklin. The editor introduced a variety into the journalism of his day by denouncing the News Letter, the government of the province, and the clergy. As a result, Increase Mather, the leading clergyman of Boston, issued an "Address to the Publick" in which the Courant was denounced as a "wicked libel," and the wrath of God was called down on the head of the editor. This paper is of special interest, as it was in connection with it that Benjamin Franklin began his career as a printer.

These early papers were printed on very small sheets, that of the Boston News Letter not being at first larger than a half-sheet of foolscap, and sometimes only printed on one side. The paper was of a much poorer quality than that now found in an ordinary market for wrapping meat, and the printing corresponded in quality with the paper. The reading matter consisted of letters from friends on political and religious subjects, and scanty news reports. It was a long time before the colonists learned the true mission and use of the newspaper.

At the beginning of the Revolution, in 1775, there were thirty-seven papers published in the country; of these, four were devoted to the interests of the king, and twenty-three to those of the colonies. The political influence of these papers was strong, and they did much to assist the colonial cause. Such men as Josiah Quincy, Samuel Adams, and James Otis were counted among their contributors. Neither the number nor circulation of papers increased during the war, but the freedom of the press was assured as one result of the struggle. The political discussions immediately following the adoption of the Constitution greatly increased the newspaper circulation of the country. In 1810 there were 362 papers published in the United States, and all but seventeen were adherents of one or the other of the two great political parties. The editors

of many of the leading papers were foreigners who had been editors in Europe, and afterward fled to America on account of trouble which their editorial utterances had brought upon them at home. The bitter attacks of some of these editors on the government were largely responsible for the Alien and Sedition laws passed during the administration of John Adams.

Only a few of these early journals have been able to continue until the present time. The Saturday Evening Post of Philadelphia, established by Benjamin Franklin in 1728, and the New York Evening Post, established by Alexander Hamilton in 1801, being the most noted of this class. It is pleasing to know that after their long career they stand to-day among the foremost periodicals of the country. William Cullen Bryant, one of our most celebrated scholars and poets, was for fifty years editor, and during the last years of his life proprietor, of the New York Evening Post. The success of these journals has been largely due to the labors of such men as Franklin and Bryant.

The changes in journalism which can be considered as causing the development of the American newspaper to its present state of excellence began about 1835. Several causes have combined to make our papers what they are, and no great number has been brought to bear upon the work at once. The growth of the industry has

been gradual and the result of the development of the country. Among the most important causes contributing to this result, may be counted the construction of railway and telegraph lines, and the perfecting of the printing press. These have been the means of cheapening the cost of publication and distribution and bringing the price of the papers within the reach of all classes, thus making a much larger circulation possible.

MAKING THE PAPER

The entire editorial work of a local weekly paper is usually done by one person. In fact, the same person is sometimes editor, reporter, compositor, and pressman. Many of these papers are founded and owned by men who are practical printers, and who obtained all their education in a printing office. It is needless to say that the literary merit of this class of journals is not of a high order. Their editors are usually much more familiar with the composition at the case than with that at the desk. Many of the more prosperous weeklies in large centers of population, however, employ editors who are specially trained for the work. Most of the journals of this class also have reporters whose business it is to gather local news and prepare the same for publication. As the paper appears but once a week, there is plenty of time to do the work well, and many of these papers have a good degree of

literary merit. But it is around the making of the great daily that our interest centers, and in connection with one of these papers we shall find every phase of newspaper work represented.

The editorial force of a daily varies according to circumstances. Many of the smaller papers find two or three persons sufficient, while those having a circulation of from 5,000 to 10,000 require a force varying from six to twelve to do the work successfully. The force of the large city dailies is divided into departments, with an editor in charge of each department, while the editor-in-chief has the oversight of all departments. It is also his duty to direct the policy of the paper. In fact such a paper can well be compared to a great department store which strives to supply its customers with all classes of merchandise, for the daily paper strives to serve up to its readers the news of the world each day. The important departments are that of foreign news, with a cable editor; that of state and national news, with a telegraph editor; that of local news, with a city editor. Then come the less important departments of society, exchanges, etc., each with its editor in charge.

The editor of each department, under his immediate supervision, has several reporters whose duty is to collect such items of news as will be of value to the department. The reportorial force of such a paper often numbers more

than fifty, and in this list will be found several who are educated and skilled writers. Many such reporters have made for themselves national and even world-wide reputations by their writings. These men are styled correspondents, and are stationed at the great centers of activity in political and commercial life, especially the capital cities of the leading countries. They must be men of sterling integrity, and possess more than an ordinary degree of shrewdness and intelligence, for they have to deal directly with the leading men in national affairs. A betrayal of any confidence bestowed would not only place the affairs of state in a wrong light, but be a breach of faith for their journal. While we often hear much said about the irresponsibility of the newspaper correspondent, it is gratifying to know that the best class of correspondents in our country possess the confidence of, and sustain the most friendly relations with, the highest government officials, and this confidence is seldom betrayed.

Other correspondents are stationed in foreign lands. The cities having the largest number from the United States are London, Paris, and Berlin. A correspondent in one of these cities often represents several papers. His daily reports include the events of the country and city which will be of special interest to American readers.

Before we can understand how the matter is

prepared for publication in the editorial departments, it will be necessary for us to look briefly at the methods of gathering news. Before the invention of the telegraph the gathering and transmitting of news was an enterprise that taxed the resources, wit, and ability of all the large journals. The rivalry existing between papers in the same city caused the managements to resort to many schemes and devices, honorable and otherwise, to accomplish their purpose. If a journal could secure and publish a piece of important news ahead of its rival, it was considered a cause for great congratulation by its friends. Such an enterprise in the language of the newspaper fraternity was called a "scoop." Carrier pigeons, pony expresses with relays of fast horses, and, later, the chartering of special locomotives and steamboats were frequent devices for the purpose of transmitting news to the office of the journal. The expense incurred in this way placed the small journals to such disadvantage as to practically drive them out of the business in large cities.

With the advent of the telegraph all journals able to pay for their dispatches, were placed on an equal footing with respect to the receipt and publication of news, and the old-fashioned scoop became a thing of the past. However, the principle underlying the associated collection of news was used before the telegraph was invented.

Several of the New York journals combined in sharing the expense of running a pony express between that city and Washington. Another association also existed for the purpose of gathering marine news by the use of fast-sailing schooners.

The value of the telegraph was at once recognized by the press, and the demands of the different journals upon the lines were soon so great that it became impossible to transmit the news promptly to all customers. As the number of lines multiplied, the difficulty increased, and this led to the formation by the proprietors of the leading New York papers of a combination for using jointly the dispatches from important news centers. This was the beginning of a movement which resulted, in 1848 and 1849, in the organization of the Associated Press.

The Associated Press has always been a strong and practical organization. It soon included all the leading journals of the country, and is to-day the greatest news gathering organization in the world, having representatives in all important cities and countries. For the purpose of gathering news in the United States, the association has the country divided into four sections; the eastern, western, central, and southern. Each division has a central office and a division superintendent. Nearly every town has a newspaper. When an event of more than local interest

occurs in any town, some representative of the local paper notifies the division superintendent, who telegraphs back the amount of space he wants to give the item, and the hour at which the line will be free for it. As the item reaches the central office the superintendent transmits it over all the circuits in his district and also to each of the other division superintendents, who in turn send it over their districts. The telegraph lines in each central office are so arranged that one sending of the dispatch transmits it to all the newspaper offices in that district which have connection with the association. As such reports are received in the newspaper offices, they are taken off by a typewriter, condensed if necessary by the department editor, and sent to the compositor.

A good share of the work on a morning paper is done during the night. As the management aims to give all the latest news, the press must be held as late as possible and enable the papers to reach the early morning trains out of the city. It will be seen at once that every means possible must be used to secure rapid work, in composition and printing, and that each department must know to a minute the time required for its work. All large offices are now supplied with linotype machines, and fast presses. If the report of an event requiring a considerable amount of space is received late, it is divided into sections,

each section is numbered, and the copy distributed among a number of compositors. In this way an account containing one or more columns can be set in a few minutes. The proof is read in a similar manner and the type sent to the stereotyping department, where the plates are quickly made, and sent to the press; the forms are locked to the cylinders, and in a few moments wagon-loads of papers are on their way to the trains. The city edition is run later, and may contain items received too late for the mail edition.

The expense of collecting news is well illustrated by the work done during the World War. Most of the leading papers maintained at their own expense special war correspondents at the front in Europe with the soldiers in action, who reported the leading events to their respective journals. These correspondents were often exposed to the greatest hardships and dangers. A prominent writer states that, in proportion to their number, the loss of life among the war correspondents was as great as that in the army, yet these men never failed to be at the front, nor to send as full accounts of the situation as were permitted by the press censor. The censor, by the way, is an officer sent out by the government to inspect all reports and suppress any information which they may contain that would be of assistance to the enemy in time

of war. While from the standpoint of the newspaper he is objectionable, from that of the government he is a necessity, and his work is undoubtedly quite important.

The general make-up or plan of the paper lies with the managing editor, who determines the amount of space for each article, what shall appear on each page, the kind and size of headlines, etc. But in doing this he must take into consideration the plans of the advertising manager, so that all advertisements may have their proper place.

No newspaper can succeed without the revenue derived from its advertisements, and advertising has become a business in itself. Several firms in Chicago and New York have for a number of years been engaged in writing and placing advertisements for great mercantile houses and other firms. Besides these, however, every large newspaper must have an advertising manager, who makes contracts with his customers, arranges space, styles, etc. This is an important and delicate business, as all advertisers want the most desirable space, and at the lowest figure. The manager has to become the adjuster, and, while trying to satisfy his customers, also have due regard for the reading matter, so that it may not appear to be sacrificed for the advertisements. Advertisements are usually paid for by the line, at so much per thousand of

THE MAIL ROOM

circulation of the paper. It will be seen by this that those papers which publish the largest editions receive the largest income from their advertisements.

The illustrations now form an important feature of the modern daily, and we often wonder how they can be made so quickly and of such good quality. A morning paper often gives an account of some event of the previous day, or which may have happened even during the night, accompanied with illustrations which are reasonably accurate. In such cases the artist of the paper hastily sketches the leading features of the scene from observation, and then fills in the detail from imagination. His drawing is made with pen and ink on a large scale, and then photographed the size desired for the cut. A zinc etching of this photograph is then made by a process similar to that used in making half-tones. The zinc process is much quicker than any other means of illustration, and modern methods have brought it to such a degree of perfection that it gives very good pictures. Many of the portraits now seen in our daily papers are better executed than were those in good grades of books published a few years ago.

DISTRIBUTION

The all-important factor in the financial success of a newspaper is its circulation, for upon

this it must depend for its revenue, both in subscriptions and advertisements. This department of the business is usually placed in charge of a manager of circulation who gives his time and efforts to securing the largest possible number of readers for his journal.

When the paper is new, the work of the manager is general, or largely that of an advertising agent. He placards the town with large and often highly colored handbills, and sends the same to neighboring cities. He often employs delivery wagons so painted as to attract special attention, and he must also employ numerous agents to act as solicitors. These agents often secure promises to try the paper for a week at the manager's expense, and by so doing retain many permanent subscribers. Offering prizes for guessing puzzles and riddles, voting contests on the plan of a lottery, offering trips around the world, or to some noted exposition, etc., are some of the extraordinary means occasionally employed by the most enterprising journals.

These schemes, however, are only temporary; the paper must depend for its permanent circulation upon its adaptability to the wants of its readers, and along this line the finest work of the circulation manager must be done. He consults with the news dealers and learns where the circulation is smallest; then tries to remedy the defect. For this purpose the policy of some

department of the paper may be changed, though this must be done with great care, or what is gained in one place will be lost in another. In making any change the interests of the advertisers must also be taken into consideration, as a change from one class of readers to another might be very much to their disadvantage.

One of the most important factors in a successful circulation is the means of distribution. A superintendent of delivery is at the head of this part of the work, and his aim is to handle the greatest number of papers in the shortest possible time. His forces are remarkably well organized; one division looks after the local circulation, another after that going to distant cities, and a third after that going to the smaller towns in the immediate vicinity. The work of the mail department usually requires from forty to seventy clerks. The wrappers for out-of-town papers are all addressed long before the hour of mailing, and with each wrapper is placed a memorandum of the number of papers required in the order. These wrappers and accompanying memoranda are so arranged as to allow the papers to be quickly packed. They are then hurried to the delivery wagons which drive with all speed to the departing trains. The large papers of New York, Boston, and Chicago now maintain newspaper trains for the purpose of

IN A NEWSPAPER TRAIN

carrying their papers to distant cities. These trains consist of mail and baggage cars, and run at a high rate of speed, often more than a mile a minute. They leave the city as soon as the first edition of the morning papers is delivered and drop their paper mail at each town as they pass. Most of the sorting of this mail is done by postal clerks on the train. Papers for the smaller towns near by are sent out on local trains, so the delivery clerks have more time to prepare them for the mail.

The local circulation is the most important, and at the same time the most difficult to manage, as all its details must be attended to at the office of publication. The two means employed for this circulation are news agents and newsboys, and the boys are by far the more important factor. Without them the newspaper business, as at present conducted, would be impossible. The papers for the districts near the office are obtained by the boys directly from the delivery rooms, but those for the districts farther away are supplied by delivery wagons.

It is interesting to watch this crowd of news venders at the delivery room as the paper goes to press, or on the arrival of a wagon in an outlying district. A motley crowd of boys, girls, men, and women, surely; yet from such a beginning have sprung some of the most noted business men of the country. The superintend-

ent of this department decides what will be the most catching feature of the issue, and gives the call as the papers are delivered to the boys, who try to outdo each other in crying it from the street corners.

The life of the news vender is certainly a rough and hard one. He has to be out in all sorts of weather, practically to live upon the streets. He must start early in the morning and work until late at night. His pay depends upon his sales, his commission being about half the price of the paper. But in spite of all these difficulties some boys earn good salaries, and save enough out of their income to enable them to go through a high school, and sometimes to college; others use their savings in starting a small business for themselves, and are invariably successful, as the habits of thrift and industry which they have formed in selling papers make them good business men; still others, by far the largest class, use their earnings in helping support the families to which they belong. In most of the largest cities newsboys' organizations have been formed. These are under the management of business men who take an interest in the boys, and strive to lead them through the organization to make the most of themselves, and also to provide for those of their number who have been unfortunate; and this they succeed in doing, for how-

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ever rough an exterior the newsboy may seem to have, you may be sure that, with rare exceptions, he has a warm heart.

From the foregoing description it will be seen that the management of a city daily is an extensive business, thoroughly organized into departments with skilled experts in charge of each. All the work connected with such a paper is exacting in the extreme. Each employee, like a soldier, must obey orders to the letter; he must go where he is sent, do what he is told, and above all things be on time. For those who succeed, the profession of journalism has ample reward, but where one succeeds many fail, as the work is such as to require remarkable fitness by natural endowments as well as by preparation.

The amount of capital necessary to conduct a large paper may be imagined from the yearly expenditures of one of the largest dailies in the country. This was $2,153,500; of this amount $220,000 went for the literary and editorial work; $290,000 for local news; $180,000 for illustrations; $92,000 for telegraph and cable dispatches; $410,500 for the mechanical department; $617,000 for paper, etc.; 337,558 miles of paper were consumed during the year, enough to go thirteen and a fourth times around the earth.

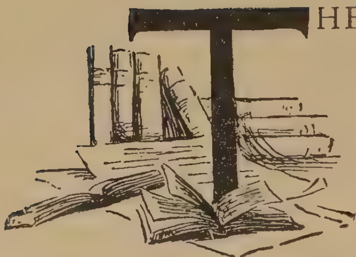
Most of the great journals of the country have become what they now are from small begin-

nings, by meeting the demands made upon them by a reading public. In this particular, the newspapers of the United States lead the world. They contain the most news, are the most original, the best printed, and the most promptly delivered. Did you ever stop to think what a daily paper contains? If not, read the first page of any of the leading journals, and try to follow out each geographical, historical, and scientific reference, and you will soon come to realize the vast amount of information laid before you each morning, and at the same time something of the influence of the newspaper press upon our lives.

Seventy-five years ago the result of a national convention or election was not known all over the country for weeks afterward. In the case of a national convention today, the radio gives the entire proceedings by voice to the whole country instantly and telegraph wires lead from the convention hall into the offices of all the newspapers in the large cities. An operator sits near the platform of the presiding officer, and with muffled key he sends over the wire a full report of the proceedings, with a description of every incident of interest. At the other end of the line is an operator at a type-casting machine receiving the report and putting it into type as fast as received. When a candidate for president has

been nominated, extra editions of the daily papers are selling on the streets of cities more than a thousand miles away almost before the applause for the winning man has died out of the convention hall. Besides receiving the news by radio the people of every city and town of the United States where a paper is published would feel themselves cheated of their rights if they failed to receive news of the result of an election by extra editions of papers by midnight of the day on which the ballots were cast.

BOOKS



THE dictionary tells us that the word "book" comes from an Anglo-Saxon word meaning letter. The Romans claim that the most ancient writing was on the leaf of the palm tree. The Latin word for leaf is *folium*, and from this we got folio, another word for book. The inner bark of the tree finally took the place of the leaf. This was called *biblos* in Greek, and *librum* in Latin; from these words we get bible and library.

The Romans early learned to write on tablets of wax, with an iron point which they called a stylus. From this the expression, "different styles," is supposed to have originated. The Romans also had a custom of running wax tablets in boards which had been hollowed for the purpose. A narrow margin was left around the edge of the board, and formed a frame to the tablet. When two of these tablets were placed together facing each other, the boards

formed a protection. They were fastened together with hinges and probably constituted the first real books. This form of book became common among the Romans long before paper was known in Europe.

Before the invention of printing, books were very scarce, even among the learned. It is impossible for us, surrounded as we are with books of all sorts and descriptions, to imagine the value of books during the twelfth and thirteenth centuries. At this time all books were written with the pen; the work was done by pious monks, who lived secluded in monasteries. These men acquired great skill in their art, and many of their books are so well made that it is difficult to distingush them from the first books printed from type. The chapters and paragraphs had elaborate headlines and initials often in red and blue, and sometimes in gold. The pages are as large as those in an ordinary geography. The paper is coarse and thick, and the bindings are elaborately gilded. It would take a scribe at least a year to copy a book containing as much reading as is found in the average school history of the United States, and he could make only one copy at a time.

From these circumstances we can see that books were very scarce and very expensive. They were usually found in the libraries of monasteries, and sometimes in the possession of

wealthy people among the nobility. If any person gave a book to a religious house, he believed that so valuable a gift merited his eternal salvation; and the most formidable anathemas were pronounced against him who dared to take away a book presented to the library of a religious institution. When a book was purchased, the affair was considered of so much importance that it was customary to assemble persons of note and make a formal record of the fact that they were present at the sale. Before 1300 A.D., the library of the University of Oxford, England, contained only a few tracts, and these were chained to tables or kept in chests in the choir of the church.

As we have seen, the invention of printing had an immediate effect upon the price of books; this made it possible for more people to possess them, and in consequence, the art of reading became useful, and was learned by a constantly increasing number.

The first books printed were copies of the Bible; other religious works followed this, and then attention was given to the works of the ancient Greek and Roman writers. These works were at first printed in the original language in which they were written. The English printers, however, soon printed translations of these works as well as of the Bible, so that they might be read without learning a dead language.

Many of the works printed during the thirteenth century are worthy of study. The printers tried to imitate the copyists, and made their type of the same style as the script letters in general use. The headlines and capitals at the beginning of paragraphs were often omitted in the type, and worked in by hand with colored inks. The work was skillfully done, and it is doubtful if the best works of modern printers can excel in beauty of design the books of these early years. But when measured by the modern standard of accuracy, they fall far short of the publications of to-day.

The lines were without title, direction words, page numbers, or paragraphs. The words were printed so close to one another that reading was difficult and tedious. Frequent abbreviations were used, and these finally became so numerous and difficult to understand that it was necessary to write a book to teach the mode of reading them. There were no capitals to begin a sentence or to distinguish names of persons or places. At first the colon and period were the only punctuation marks used; the others have been added from time to time, as the standard of accuracy has been raised.

The transition from such books as these to the best productions of the modern bindery has been very slow. If one examines books printed as late as fifty years ago, and compares them

with those of to-day, he will notice a marked difference in the styles of type, illustration, binding, and paper; all seeming to be in favor of the later book. The processes of type-setting, electrotyping, and printing already described, apply to books as well as other publications, and do not need to be repeated. There are, however, a few processes directly connected with the making of a book that will interest you.

The beginning of a book is in the hands of the author, who must prepare his manuscript for the printer. If the book is to be one of value, the preparation requires great care and often necessitates extensive research to obtain the information desired. The manuscript must be plainly and carefully written; capitals, punctuation, and paragraphs must appear as the author desires them in the book. Now that the typewriter is so common, most manuscripts are typewritten before being placed in the hands of the printer. In any case, the author must write only on one side of the sheet.

If the book is to be illustrated, the drawings have to be made especially for the purpose. These drawings are different from those used for other purposes, and an artist requires considerable experience as well as skill to make them. You may sometime see the original drawings used in illustrating some book; if you do, you will notice that they are much larger

than the illustration made from them, and that the lines are coarse, giving the picture a very bold appearance. This is necessary on account of the method of making the cuts for the illustration.

Except in expensive works which use fine engravings, nearly all the cuts are made by photographing and then etching the design on the plate. This will be understood better from following the making of a half-tone cut, such as the illustrations in this book are printed from. The illustration is first photographed on glass (the negative being carefully developed to make it as perfect as possible). Its appearance when finished will be such that we might not recognize it, for the camera in which this negative is taken has a peculiar arrangement made especially for tnis purpose. This consists of a glass plate made into little squares and placed just in front of the sensitive plate upon which the negative is formed. The result is, that the negative contains a picture made up of dots whose size and density have been determined by the lights and shade in the illustration. The size of the dots, and consequently the finish of the cut, depend upon the fineness of the ruling on the glass plate. These rulings vary from seventy-five to two hundred lines to the inch. Usually two plates are used, each being ruled diagonally from opposite corners. When put together the

lines cross at right angles and form the desired screen. The finest rulings produce the best finished cuts, and are used for the best grade of illustrations.

The next process is that of reversing the negative so the positive will face the right way when printed on the page of the book. As soon as the negative is dry, it is coated with a solution of rubber. When that is dry, a thick coat of collodion is spread over it to give it strength. The glass is now placed in a weak solution of acid, and in a few moments the gelatin film loosens and is peeled off. This is laid, face downward, upon another plate of glass. A plate of metal, usually copper, has been prepared to receive the print from the negative in the same manner that the paper does from the negative made for you by your photographer. The reverse negative is locked down upon this and placed in a printing frame and exposed to the strong electric light for a short time. When the print is developed, we have a photograph of the illustration upon the copper plate. The secret of the process lies in the fact that the action of the light upon the gelatin of the plate makes it insoluble, while the other parts can be washed away by running water. The plate is then heated over a furnace until the picture is burned into the surface. The metal possesses a silver hue, and the picture shows in a clear, dark

mirror. By placing the plate in acid, that portion around the picture is soon eaten away, leaving the cut raised above the surrounding surface. The lights and shades are also etched at the same time. The plate is then inspected and perfected if necessary by an engraver, and then nailed to a block to make it type high, when it is ready for the press.

Half-tone printing has done much to make good illustrations possible at a comparatively small cost. It is the result of the latest application of scientific knowledge to the art of printing, and requires skill on the part of the workmen. If the illustration is printed from an engraving, the plate is made by the engraver directly from the picture, by using hand tools, and to some extent the process of etching. Engravings form our most expensive illustrations, and are found only in the higher priced books and magazines. Ask the librarian at your public library to show you a book illustrated with engravings. You will probably find some of the higher priced magazines illustrated in this manner.

The success of the illustration depends as much upon the printer as upon those who make the cut. The skill of the printer is shown in bringing out the lights and shades so as to produce the best effect. He does this by a process known as "overlaying." When the first proof of a page containing illustrations is taken,

the picture is often a mere blur, intensely black in some parts and nearly white in others. You probably have seen such pictures in cheap newspapers. This is caused by too much or too little pressure from the platen. The pressman proceeds to even up the process by planing off from the wide side of the block where it is too heavy and pasting on paper where it is too light. In fine work this adjustment is very delicate—sometimes requiring only a thickness of the finest tissue paper to produce the desired result. "Overlaying" is one of the secrets of producing the finest illustrations that come from the press.

After printing, the sheets are carefully dried. Many large binderies have drying closets which are made on about the same plan as the dryers in a laundry. While these closets dry the sheets very rapidly and consequently save considerable time, their work is not considered satisfactory for the best grade of books, and on these the old process of drying in the open air is still used. All copies of the same signature are placed together, and the whole is put in a powerful press called the standing press. Sometimes the sheets are placed between the boards and sometimes they are laid in the press *en masse*. The pressure to which the sheets are here subjected presses back into place the indentations made by the type in printing, so that the surface of the paper is again made smooth. If you run

your finger over the page of a nicely printed book, you will find it quite smooth, but if you try the same experiment with a newspaper, you will be able to feel the impression made in printing. This is because the paper was not subjected to the second pressure.

After the sheets leave the standing press, they are ready for the bindery; this may be in the same building where the printing is done, or it may be entirely separate. Many large firms do nothing but binding, and many printing firms prefer not to invest capital in a bindery.

The first process in the bindery is folding. In making the most expensive books this work is usually done by hand and must be very accurate. Women and girls do much of this work, and become very skillful at it. The paper is creased with a small folder of ivory or bone. The appearance of the book depends very largely upon the accuracy of the folding. In nearly all of the binderies the folding is done by machines. A single machine will fold from 2,500 to 3,000 signatures an hour. Folios have one fold, quartos two, octavos three, 16mos four, etc.

A figure at the bottom of the first page of each sheet indicates the order in which the sheets should occur in the book, and they are placed together accordingly. This process is called gathering.

A gathering table is used in large business

houses, by means of which the work can be done very rapidly and with the least amount of labor. The table is so arranged as to turn slowly. The signatures are placed in order near the edge of the revolving platform. Girls sit around the table and pick off the signatures in order as they come along. If there are twenty signatures in a book and twenty girls do the gathering, and the table revolves once a minute, 400 signatures, or twenty complete books, would be gathered in that time.

The book is now placed in the signature press to make it solid. It is then prepared for sewing by having grooves cut in the back with rapidly revolving circular saws. Twine bands to which the leaves are sewed are inserted in these grooves. The sewing is done in a frame called the sewing bench. Each sheet is sewed around twine bands, the number of bands depending upon the size of the book. The durability of the book depends, to a large extent, upon the sewing's being well done. If poorly sewed, the leaves soon become loose. In well bound books the sewing is done by hand. In many small and cheap books and pamphlets, the sewing is done by wire cable, or staples, on machines which work very rapidly. Such books, however, are not durable, as the tightness of the binding combined with the stiffness of the wire causes the leaves to soon break loose.

After stitching, the book is ready for the operations known as forwarding, and which include all processes having for their purpose the holding of the book together and strengthening it. The back edges are glued together to strengthen the volume; the strings to which the leaves have been sewed are left with ends from two to three inches long. These ends are scraped, so they will not show in the binding. The volume is next rounded, making it convex on the back, and concave in front. This is done by a workman's hammering the book, while he so draws the sheets with his left hand as to bring them into the desired position. A groove is now made for the stiff boards which form the cover. This is done by placing the volume in a press made especially for the purpose, so that the back will extend beyond the edges of the press. By properly hammering the back, the paper is forced out over the edges, forming two ledges, one on each side, and into these the boards of the cover are made to fit. The arrangement is readily seen on any well bound book.

If the edges are to be cut, this is done before the cover is fastened on. Cutting is now mostly done by a machine, though some binderies still do it by hand. The tool used resembles a carpenter's plane, and is used in much the same manner. The volume is placed in a press with one end slightly projecting. This is planed off,

and the volume reversed and the other end finished. The book is then struck forcibly on the bench and the back flattened so as to flatten the concave front, which is cut in the same manner as the ends. When released from the press, the volume springs back to its former shape.

The stiff boards which form the cover are next applied. In well-bound books these are held in position by passing the ends of the threads already described through holes made near the edge of the board, and firmly gluing them to the inside of the cover. This makes a strong and durable binding.

The little appendage, called the headband, is found at the top of the back of the best bound books. This usually consists of a silk or cotton cord, but in expensive bindings it is a strip of vellum or pasteboard around which colored silk threads are twisted. If the book is to have a uniform cloth cover, this is applied to the boards before they are fastened in position; but if bound in whole or half leather, the cover is put on after the boards are attached.

The last step is finishing, and much capital and great ingenuity have been invested in this branch of the business. The result is a great variety of beautiful and appropriate designs, the description of which would fill a volume much larger than this. In the smaller books, the

edges are left either white or are gilded; in the larger ones they are frequently colored. The marble effect so common is produced by skillfully managing mixed colors floated on water, after much the same manner as in marbleizing slate. (See volume, "Minerals," page 161.) The edges of the book are barely touched to the water, and the color adheres. Gilding is usually done by gluing gold leaf to the edges. Gilt designs on the covers are stamped with hot tools which fix the gilt in place. Many of the designs on cloth covers are stamped with dies working in a press made for the purpose. After finishing, the books are placed in a press until dry, when they are ready for sale.

Centuries ago, the "wise man" said, "Of the making of many books, there is no end," and truly his prophecy has been fulfilled. The number of books published each year by the four leading nations, France, Germany, England, and the United States, would constitute a large library. In the production of books, the United States does not hold first rank among the nations of the world, as to the number of her publications; but as to the skillful work, and the mechanical quality and finish of the books, she is second to none. Books are so common and so cheap that every home can be cheered and enlightened by their presence, and everyone should plan to add a few good books to his pos-

sessions each year; for a good book contains the choicest words, best thoughts, and richest experiences of a great soul, and is often a more valuable companion than a friend. On the walls of the rotunda of the Chicago public library, set in beautiful mosaic, we find this inscription:

"He that loveth a book will never want a faithful friend, a wholesome counselor, a cheerful companion, and an efficient comforter."

"Consider," says Emerson, "what you have in the smallest chosen library. A company of the wisest and wittiest men that could be picked out of all civil countries in a thousand years, have set in best order the results of their learning and wisdom."